NASA Tech Briefs

THE DIGEST OF NEW TECHNOLOGY

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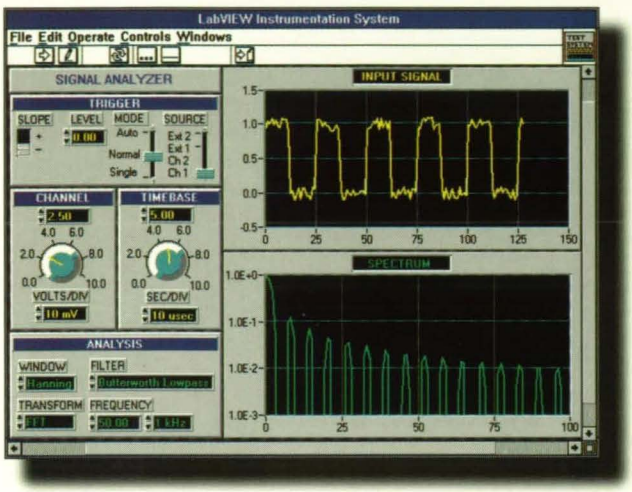
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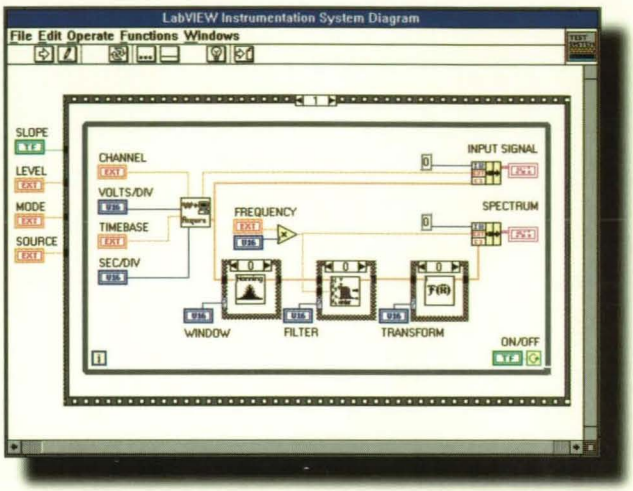


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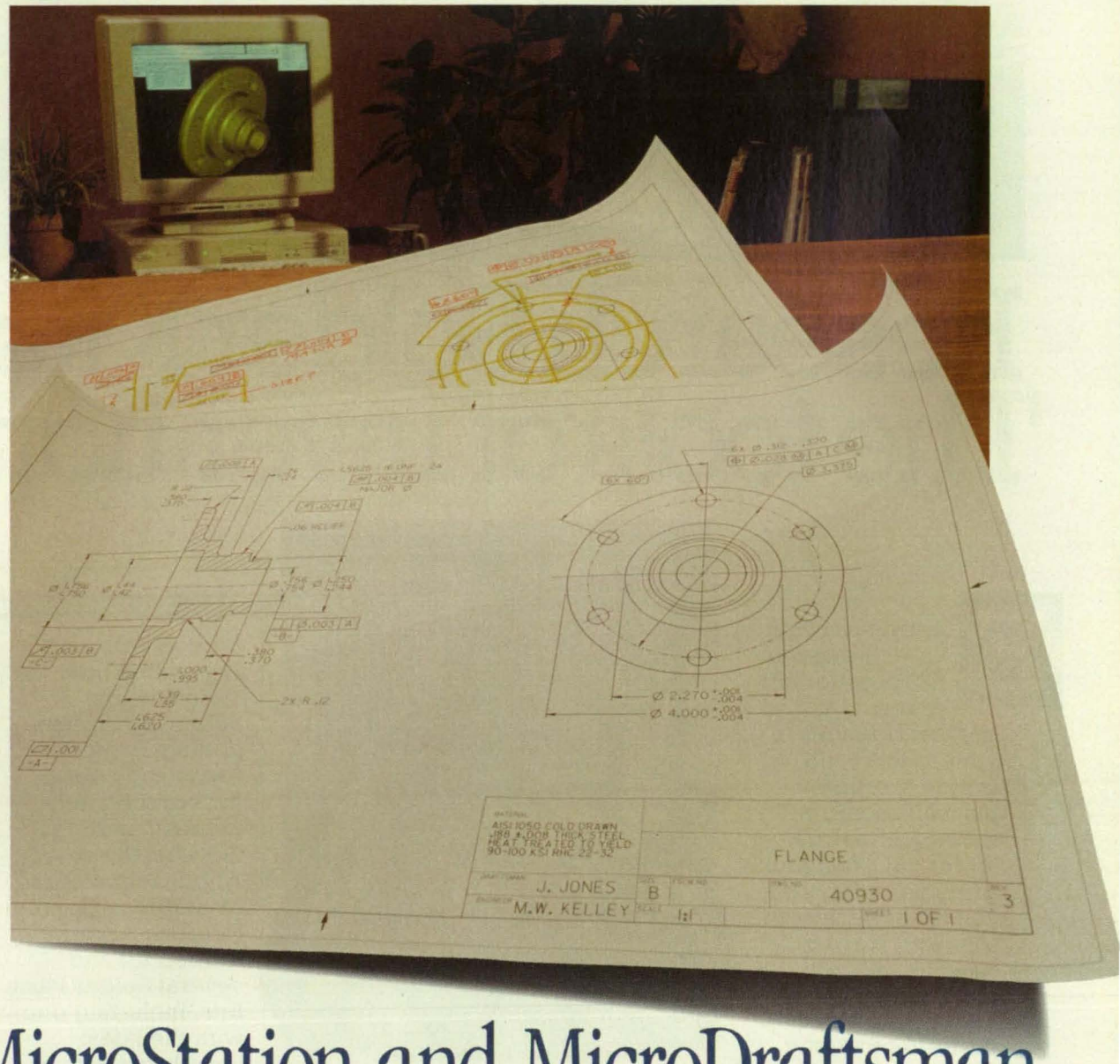
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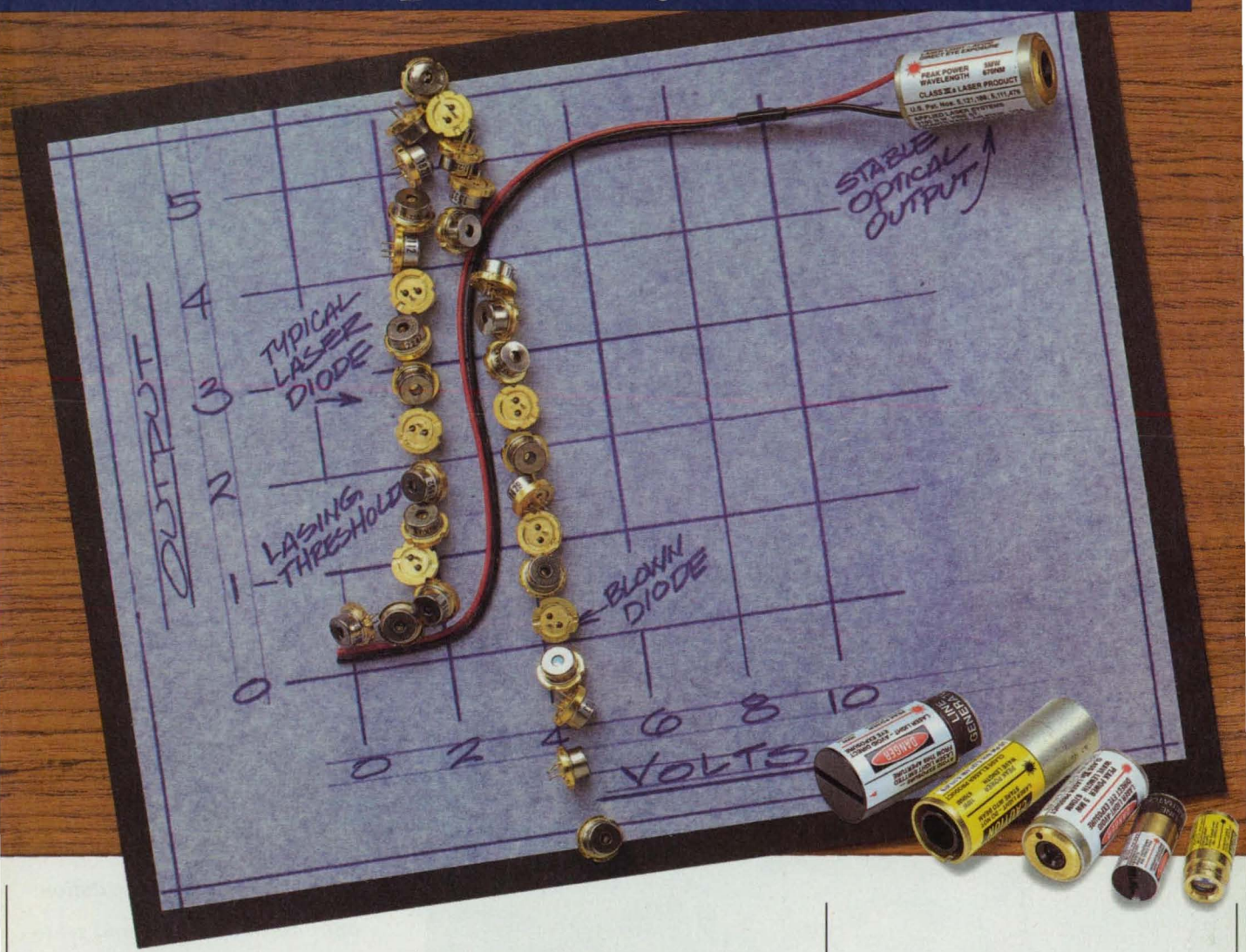
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...the laser diode destined for your product application is completely protected against the forces of electro-static discharge, temperature and handling abuse. That's because a raw laser diode is a fragile and highly volatile device with extreme threshold behavior that will quickly "blow up" under unstable environmental conditions. The typical laser diode is capable of turning on in "one millionth" of a second...and one very short "mistake" usually results in total destruction, rendering the laser diode useless. Applied Laser Systems (ALS) has solved this problem and makes the laser diode usable in the real world.

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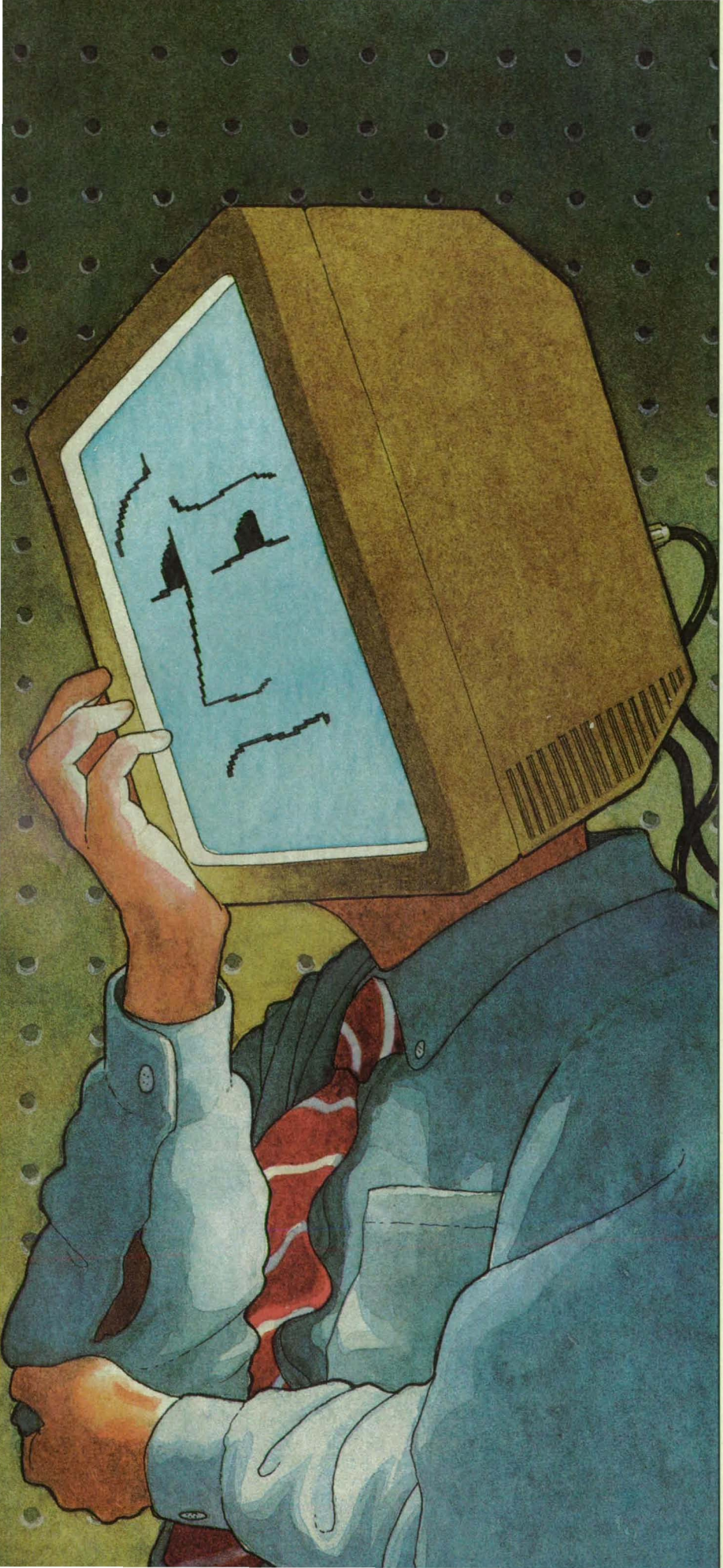
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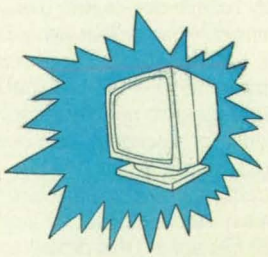
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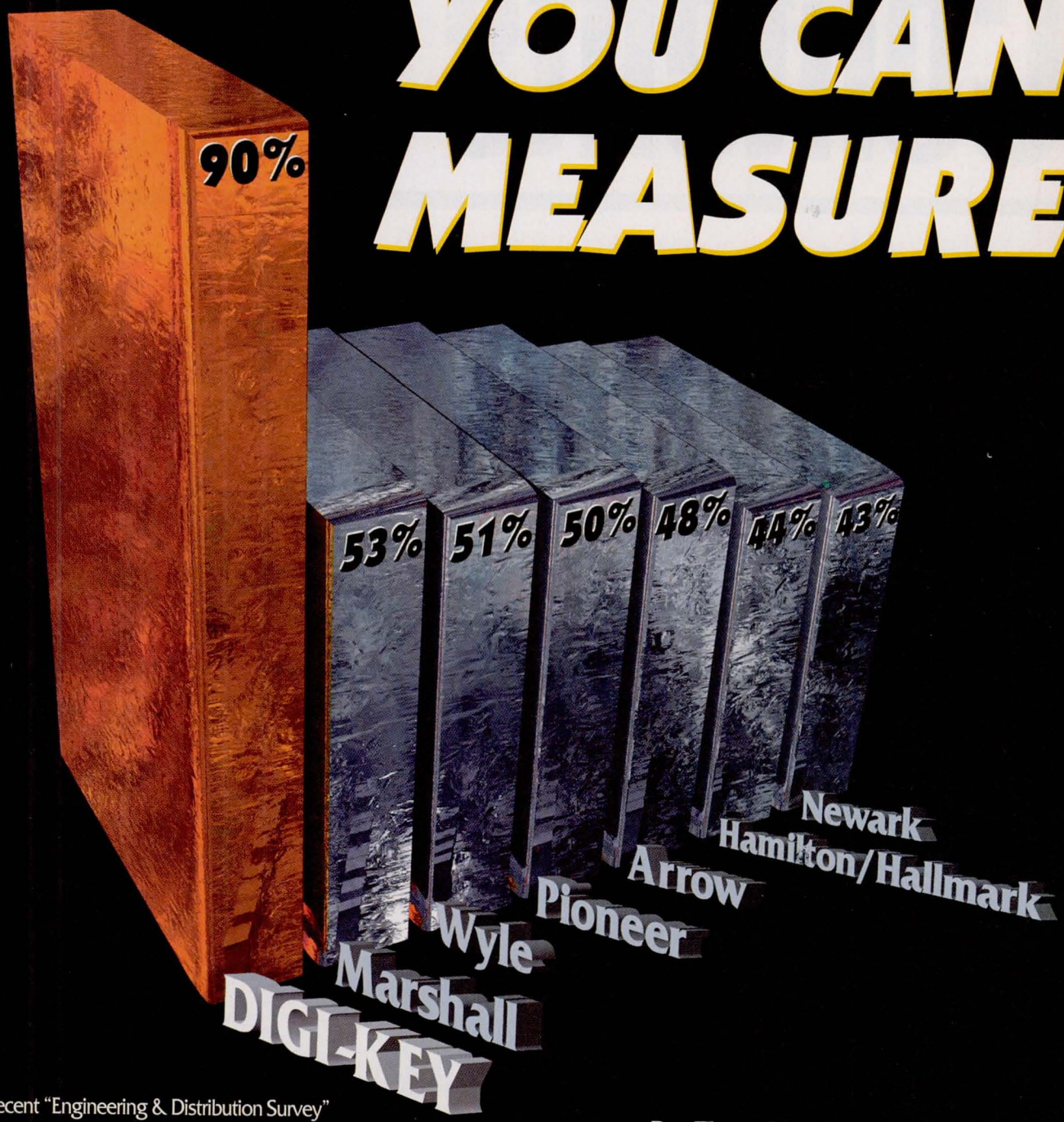
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Note: Since the bases varied for each distributor, direct comparisons should not be made.

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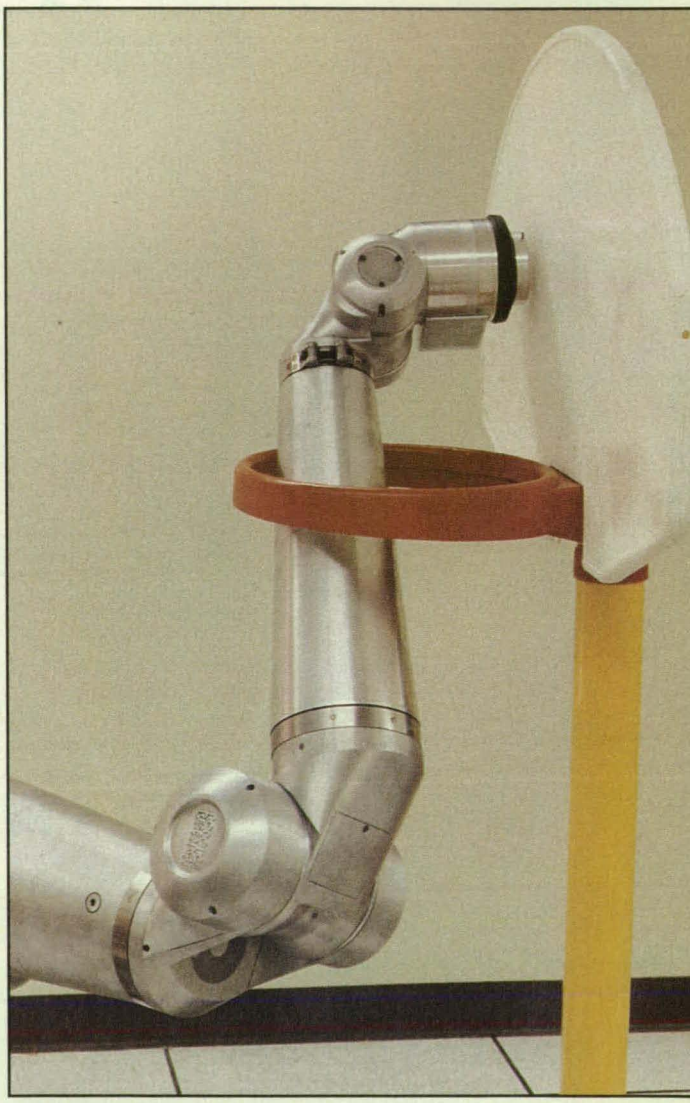
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Jet Propulsion Laboratory researchers have developed efficient algorithms for the forward kinematic mappings of seven-degree-of-freedom (DOF) robotic manipulators with revolute joints. A seven-DOF manipulator has one redundant DOF, represented here in terms of a parameter called the "arm angle," because six DOFs are sufficient to specify the end effector's position and orientation. The redundant DOF is used to perform simultaneous additional tasks such as reaching around an obstacle or maintaining a posture while positioning the end effector. See the tech brief on page 66.

Photo courtesy Jet Propulsion Laboratory

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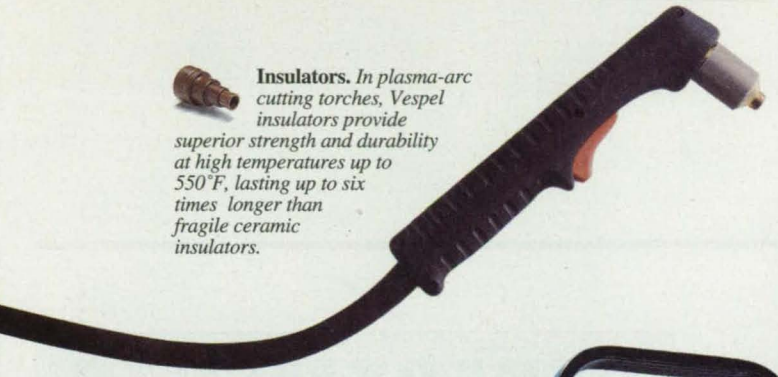
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Insulators. *In plasma-arc cutting torches, Vespel insulators provide superior strength and durability at high temperatures up to 550°F, lasting up to six times longer than fragile ceramic insulators.*



Seal Rings. *In the assembly of automobile transmissions, Vespel seal rings reduce costs by replacing expensive metal rings, which can fracture or deform during assembly. They also reduce warranty costs by producing a better seal.*



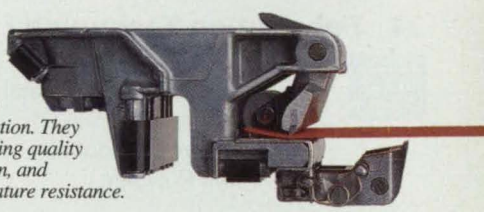


Thrust Washers. *In farm tractor transmissions, Vespel thrust washers reduce costs and manufacturing time by eliminating the need for secondary machining. Vespel washers also exhibit high performance and low wear with limited or no lubrication.*

Bearings. *In photocopiers, Vespel composite idler gear hub bushings are a cost-effective alternative to metal. The Vespel parts provide ultra-high temperature resistance and dimensional stability while offering a low coefficient of friction, as well as long life without lubrication.*



Bushings. *In aircraft engine vanes, Vespel bushings withstand high-frequency vibration dithering and offer excellent stability and lubricity at high temperatures. They also reduce assembly time.*



Wear Strips. *In textile equipment, Vespel tenter frame clip wear strips reduce costs by eliminating the need for lubrication. They also improve textile manufacturing quality by eliminating oil contamination, and provide good wear and temperature resistance.*

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On the cover:

Scientists at Ames Research Center have developed a computer model of the Earth's "breathing," removing carbon dioxide from the atmosphere during plant growth and releasing it as soil microbes decompose plant debris. Based on a unique combination of satellite, climate, and soils data, the CASA biosphere model could help researchers predict the planet's response to future global warming. This image illustrates microbial respiration during 1987. Turn to NASA's Innovators on page 16.

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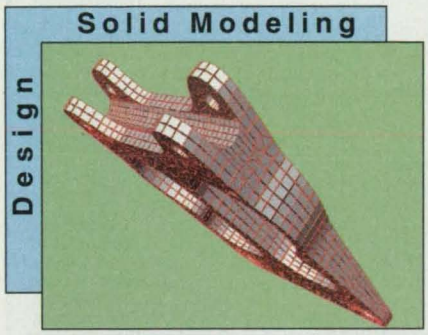
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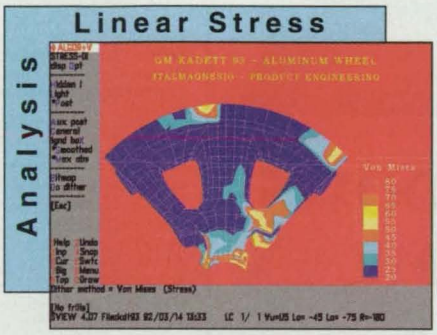


#1: Power Booster Pak

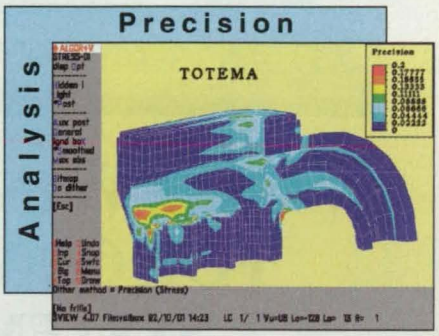
Includes Everything Shown Here:



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Model courtesy of Italmagnésio Sao Paulo, Brazil.



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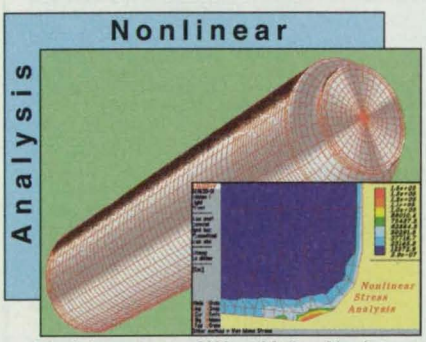
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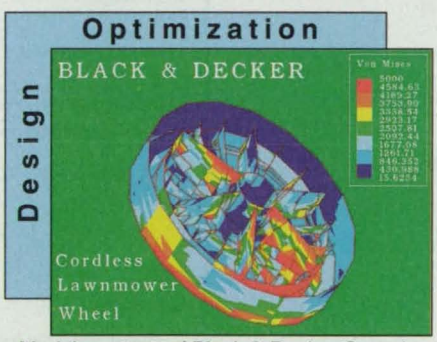
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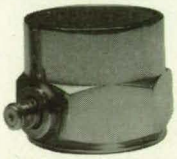
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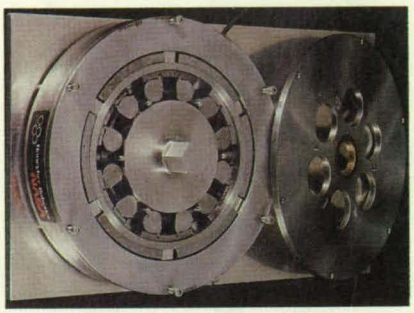
Neural Network With Dynamically Adaptable Neurons

(US Patent No. 5,299,285)

Inventor: **Raoul Tawel**, Jet Propulsion Laboratory

Many complex problems, such as best path location, can be solved more quickly with analog neural networks than with parallel processing on a digital computer. A neural network, single-layer or multilayer, "learns" by experience. Mr. Tawel's neuron elements dynamically adapt along with the synapses that define the rules of the problem. By adaptively changing gain in a manner similar to the change of weights in the synapses' I/O elements, the neurons enhance the learning process and conserve time.

For More Information Write In No. 740



Electromagnetic Brake/Clutch Device

(US Patent 5,275,261)

Inventor: **John M. Vranish**, Goddard Space Flight Center

Electromagnetic brakes that depend upon friction for their holding power are commonly used with electric motors and other drives, but lack sufficient holding force for many applications. A new electromechanical device increases holding forces and operates as a precision torque relief clutch that can release under loads. Mr. Vranish has devised a tripping technique to release locking rollers under load and the means to reduce magnetic circuit air gaps as well as provide smooth, safe, and instant disengagement for the locking rollers during unlocking.

For More Information Write In No. 745

Anode for Rechargeable Ambient-Temperature Lithium Cells

(US Patent No. 5,294,503)

Inventors: **Chen-Kuo Huang**, **Subbarao Surampudi**, **Alan I. Attia**, and **Gerald Harpert**, Jet Propulsion Laboratory

Lithium-based batteries have the high energy density and low weight needed for advanced space, communications, and automotive applications. However, lithium is highly reactive with most inorganic and organic electrolytes, which results in lower cycling efficiency. Further, prolonged cycling produces large quantities of dendritic lithium, increasing the risk of thermal runaway. Using Mg_2Si as an anode material at ambient temperature results in formation of crystalline Li_1Mg_2Si that offers superior stability towards organic electrolytes, a large capacity for lithium storage, good reversibility, and satisfactory mechanical strength after cycling. Since there is no free lithium available, there is no dendritic growth.

For More Information Write In No. 741

System for Installation and Replacement of Components in Hostile Environments

(US Patent No. 5,290,121)

Inventors: **James L. Dolce** and **Andrew L. Gordon**, Lewis Research Center

Lewis researchers have designed a clamping apparatus to facilitate installation, maintenance, and replacement of service equipment in hostile environments such as space and nuclear facilities. The clamp permits easy removal and replacement of service units manually or with remotely-controlled robotic end effectors. It employs a Geneva cam driver with a spline, engagement roller, disengagement roller, and interlocking formation; a drive shaft coupled to the driver's spline; and an operating mechanism that rotates the shaft to engage and disengage the unit. An efficient thermal interface for temperature control of the service equipment is also provided.

For More Information Write In No. 742

Extra-Corporeal Blood Access, Sensing, and Radiation Methods and Apparatuses

(US Patent No. 5,261,874)

Inventor: **Kent D. Castle**, Johnson Space Center

Access to flowing blood is needed in various medical procedures, including kidney dialysis, killing viruses and bacteria in the blood, and treating blood components with energy such as radiation, electromagnetic force, or atomic particles. The new apparatuses provide access ports and/or windows for radiating and analyzing blood on tubing or chambers through which blood flows. They can be implemented with existing blood processing equipment and permit rapid treatment of a person's or animal's entire blood supply.

For More Information Write In No. 743

Active Antenna

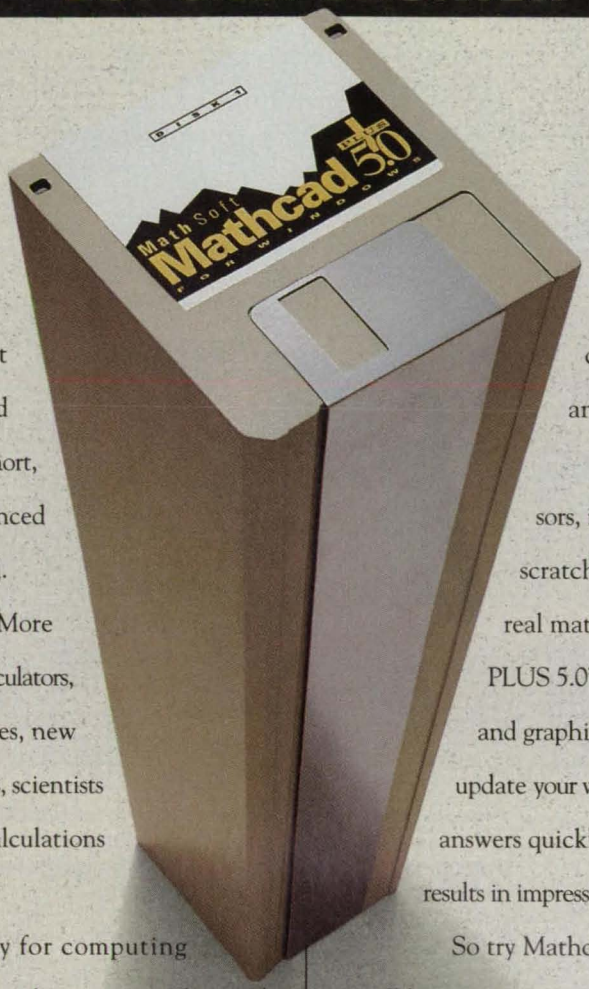
(US Patent No. 5,296,866)

Inventor: **John F. Sutton**, Goddard Space Flight Center

A highly stable active antenna comprises an antenna with positive inductance and resistance and a circuit with negative inductance and resistance. The magnitude of the circuit's negative impedance is on the order of, but slightly less than, the antenna's positive impedance, resulting in a small positive antenna-plus-circuit impedance. The novel configuration employs positive feedback from a voltage-controlled current source to greatly increase the antenna's effective area and thus its sensitivity.

For More Information Write In No. 744

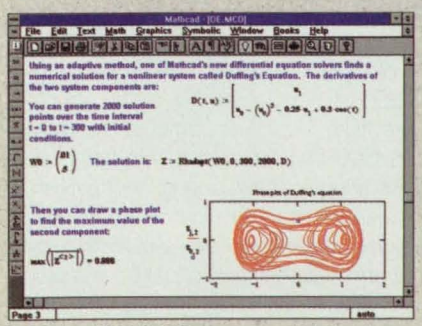
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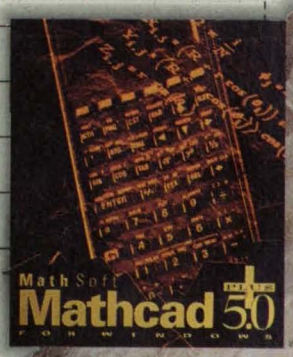
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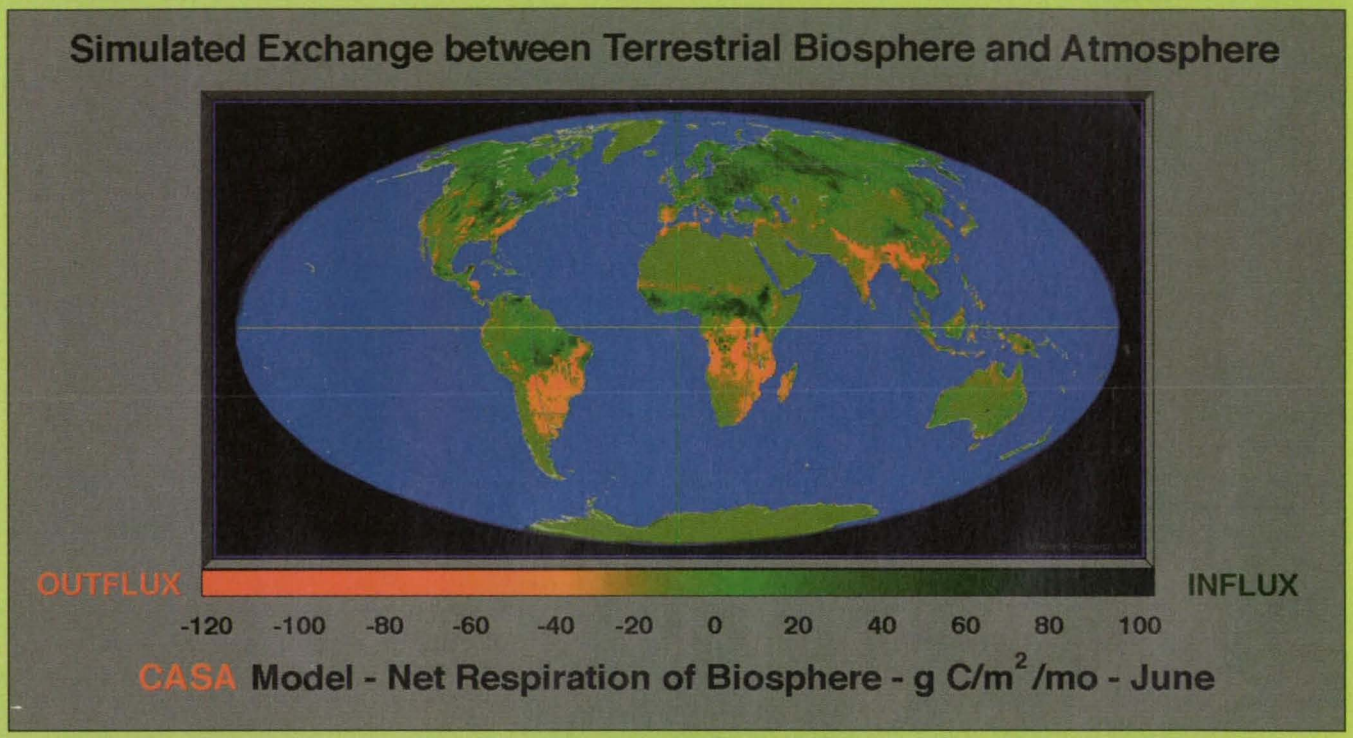
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For More Information Write In No. 650

NASA's INNOVATORS



This computer-generated global projection emulates patterns in the production and absorption of CO_2 by the Earth's land and atmosphere in a typical June. Areas where plant growth results in a net CO_2 uptake are green; red indicates net CO_2 release from decay of plant matter by soil microbes.

Scientists have a new tool to help predict how our planet will respond to increases in atmospheric carbon dioxide, the gas billowing at the center of the global warming debate.

A computer model created at NASA's Ames Research Center offers a unique view of the Earth's "breathing." Based on monthly observations of climate, sunlight, and ground vegetation, the model simulates the planet removing CO_2 from the atmosphere during plant photosynthesis and releasing it as soil microbes decompose plant debris.

Gases such as CO_2 reside in the atmosphere and absorb long-wave radiation emitted by the planet's surface. Increases in their concentrations could trap heat in the atmosphere and gradually warm the planet, resulting in an increasing "greenhouse effect."

Many of the fundamental questions about the global carbon cycle can be addressed using simulations such as the Carnegie Ames Stanford Approach (CASA) model, which emulates seasonal patterns in the functions and interactions of the biosphere and atmosphere. The CASA model is a product of Ames' Earth System Science Division in cooperation with the Carnegie Institute and Stanford University faculty and is funded by NASA's Office of Mission to Planet Earth.

CASA is the first ecosystem carbon flux model to incorporate satellite images of the global land surface, collected by the Advanced Very High Resolution Radiometer (AVHRR), a sensor aboard the National Oceanic and Atmospheric Administration's NOAA-9 environmental observation satellite. Launched in the late 1970s to provide more global and continuous coverage of ecological phenomena, the sensor gives a detailed assessment of vegetation density in relatively small areas. "We've gone from the resolution of a climate model cell, about the size of Colorado, to an area approximately 60 miles square," said Ames/Johnson Controls research scientist Christopher Potter.

The AVHRR takes readings of infrared light which, when combined with ground-based temperature, precipitation, and solar radiation readings, yield an estimate of net photosynthesis. The model also takes into account soil texture and vegetation type—leafy material, twigs and stems, rotting wood, and roots—important because different types of plant material decompose at different rates.

"By developing correlations between the raw data from both fieldwork and satellites, we're able to combine them into something useful," said Ames researcher Steven Klooster. "In the past, we could look only at directly sensible things such as temperature from satellites. Modeling enables us to produce a map of CO_2 distribution, something not directly sensible."

The model shows that annual production of CO_2 from soils is at least ten times the annual increase of CO_2 in the atmosphere from fossil fuel combustion. However, CO_2 from plant decay is balanced by the annual uptake during plant growth, whereas even a slight imbalance caused by human activities such as burning fossil fuels and deforestation could have a dramatic effect. Any small degree of global warming could cause temperature-sensitive soil microbes to decompose organic matter more rapidly, thereby releasing more CO_2 into the atmosphere. Elevated CO_2 would, in turn, raise temperatures further to renew the cycle.

"With the simulation, we begin to see local processes applied on a global scale,"

Klooster said. "This carbon has been stored in the soils for tens of thousands if not millions of years and man's recent activity has begun releasing it."

The researchers' next step is to extend the simulation to ten years. "We have global satellite imagery and real climate measurements—not just long-term averages—for the last decade," said Potter. "These can be significantly affected by the types of volcanic eruptions and El Niño events we've had in recent years. Our goal is to determine how sensitive this breathing process is to year-to-year changes in climate."

Independent measurements help to verify and refine the simulation. "There are up to 50 sites around the planet where scientists have been collecting data for years," said Klooster. "We've used that data to make the model more realistic."

The team also is looking for ways to bridge the gap between global coverage, for which there is only monthly satellite data, and daily and even hourly processes that may influence the carbon flux. "We know from field experiments that there are processes occurring on shorter intervals that are very important—such as when it warms up very quickly and plants burst into activity in the northern regions," explained Potter. "These critical transition periods are averaged out when you look at months or seasons, but we're trying to represent them mathematically to make the model more realistic."

CASA has yielded clues to its own refinement. "We've discovered that information about soil texture is critical in reproducing the proper breathing sequence, yet the available soil data is less reliable than what we have for climate and from the satellite," Potter said. "Many areas are difficult to sample or even inaccessible, such as the northern tundra. Soils data stands out as an area in which we need international scientific cooperation for improvement."

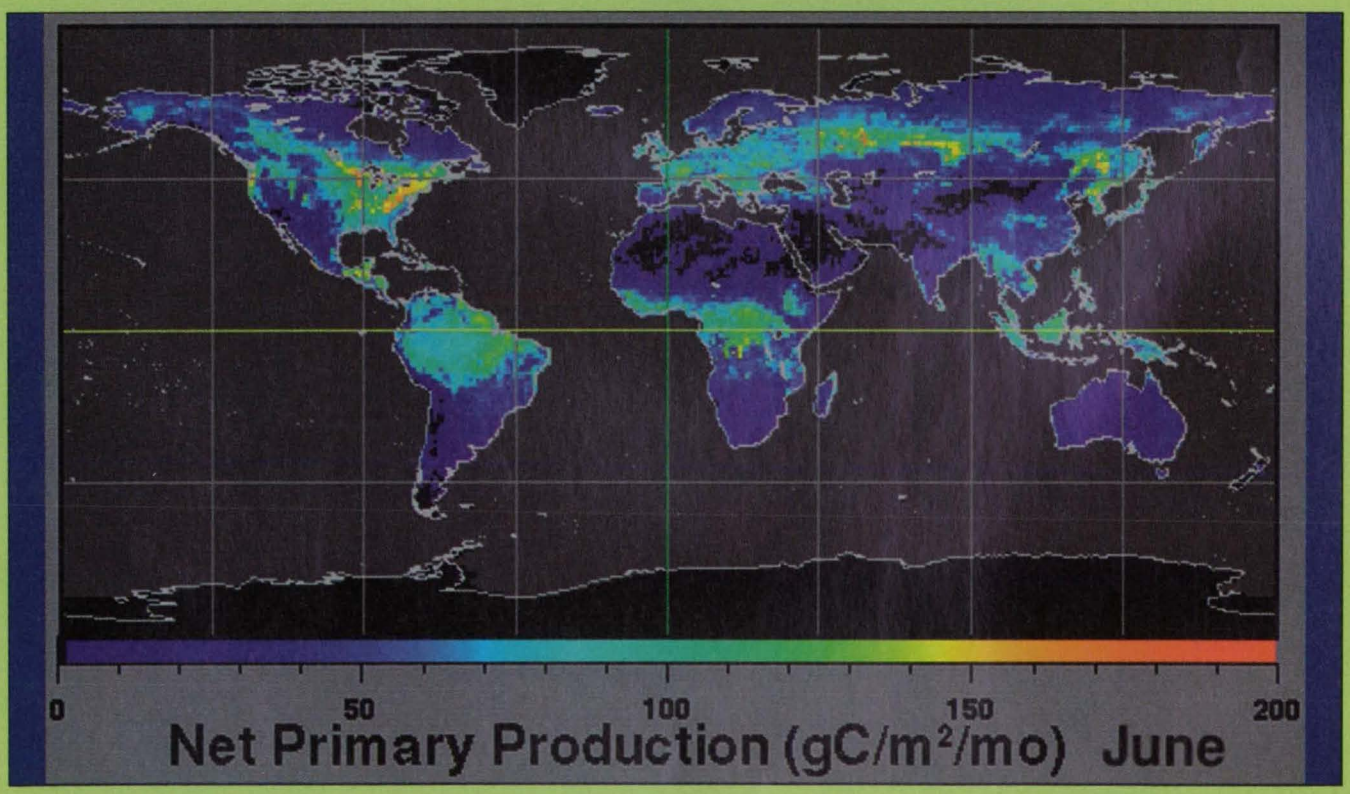
Potter said it also has proven difficult to simulate areas converted to permanent agriculture because of limited understanding of how human management affects the ecosystem. "We know from experimentation that if humans are disturbing the soil, tilling it for example, the rates at which microbes metabolize are accelerated. In trying to model the subtleties of the system, transitions caused by humans become very important, yet the global satellite doesn't pick them up."

To address such distinctions in land characteristics, the researchers employ a technology known as the Geographic Information System (GIS), which provides layers of data representing continuous information on climate and vegetation. Individual calculations are carried out at each of the global model's 14,000 grid cells before the simulation is constructed. This permits application of a slightly different algorithm in cells designated as cultivated land. The team hopes to apply the same technique to distinguish areas receiving applications of chemical fertilizers.

According to Potter, the CASA model could be used to study the role of forests and land use in global biochemical cycles, such as the effect on atmospheric CO_2 as rainforest is replaced by farmland. Other potential uses include determining the effects of population increases and irrigation techniques, as well as studying other important greenhouse gases such as nitrous oxide and methane.

Understanding the links between large environmental systems, such as the Earth's land surface and the atmosphere, is a fundamental goal of NASA's Mission to Planet Earth. By collecting, analyzing, and distributing its findings, the project hopes to support informed policy decisions regarding human action and its effects on the Earth's environment. ❑

For more information about the technologies described above, contact Christopher Potter, NASA Ames Research Center, Mail Stop 242-4, Moffett Field, CA 94035-1000, Tel: 415-604-6164, Fax: 415-604-4680.



The above map, computed from satellite, climate, and soils databases in the CASA biosphere model, illustrates the fixation of CO_2 by plants in June after correcting for metabolic requirements.

New Product Ideas

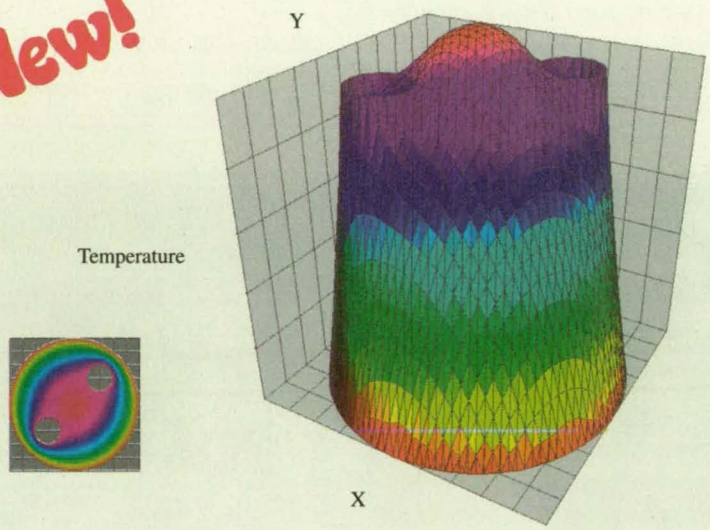
New Product Ideas are just a few of the many innovations described in this issue of *NASA Tech Briefs* and having promising commercial applications. Each is discussed further on the referenced page in the appropriate section in this issue. If you are interested in developing a product from these or other NASA innovations, you can receive further technical information by requesting the TSP referenced at the end of the full-length article or by writing the Technology Utilization Office of the sponsoring NASA center (see page 20). NASA's patent-licensing program to encourage commercial development is described on page 20.

Improved Separators for Rechargeable Lithium Cells

New separators would prevent short circuits and thereby increase cycle lives of secondary lithium cells. A AA-size cell with the proposed separator would exhibit a specific energy of about 120 W-h/kg and would be useful in applications requiring high energy density and rechargeability. (See page 42.)

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Improved Micromachined Transducers

These transducers would feature autonomous commanded calibration, monitoring, and adjustment during operation, and protection when nonoperational. They would provide completely remote measurement, control, health monitoring, treatment, and the like, via telemetry commands. (See page 24.)

Hermetic Packages for Millimeter-Wave Circuits

Advanced hermetic packages are being developed for electronic circuits that operate in gigahertz range. This would open a new line of commerical circuits that are small, rugged, lightweight, and inexpensive to produce. Potential applications are in automotive, communication, radar, remote sensing, and biomedical areas. (See page 24.)

Eye/Brain/Task Testbed and Software

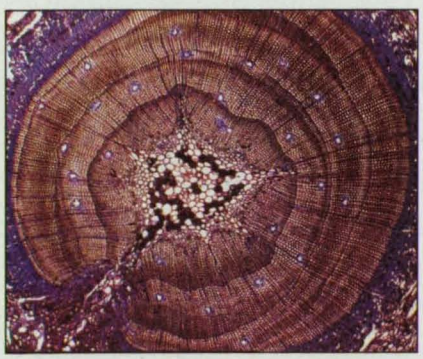
This testbed records encephalograms, the movement of eyes, and the structures of tasks to provide comprehensive data on neurophysiological experiments. The testbed is used to develop interactions between human brain waves and computers. (See page 72.)



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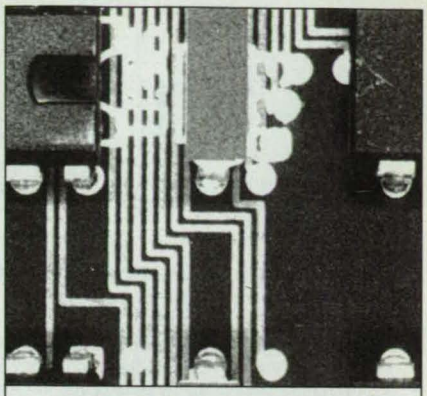
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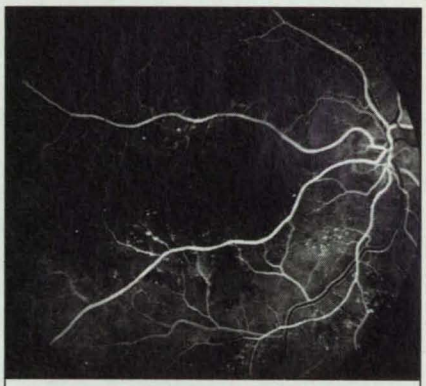
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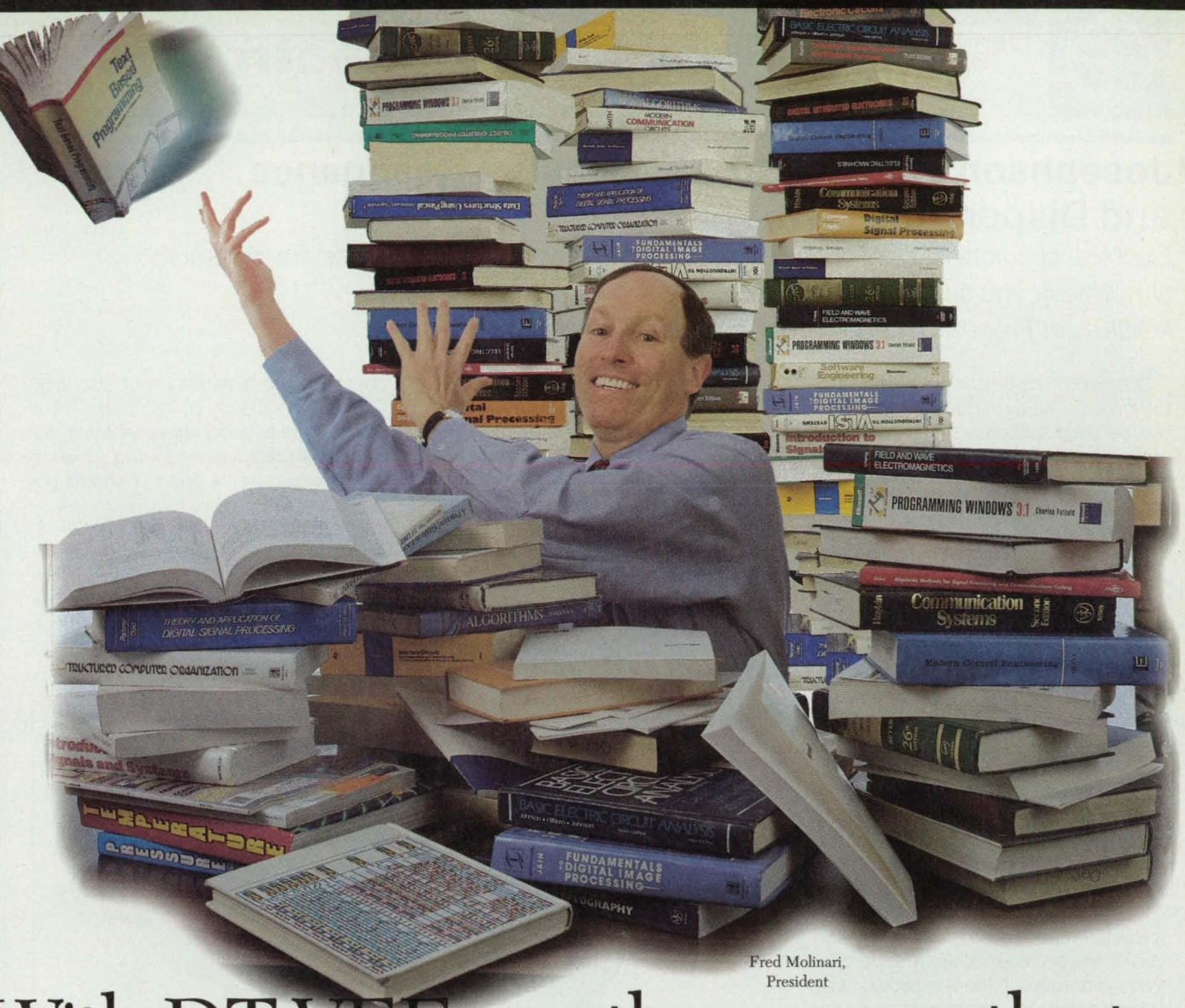
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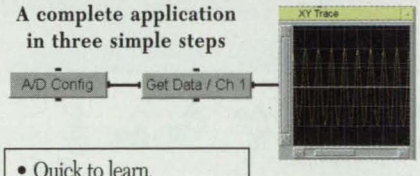


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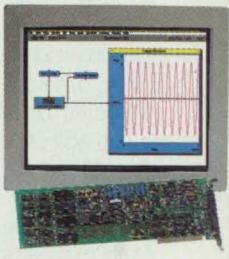


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Josephson Junctions Help Measure Resonance and Dispersion

Electrical characteristics of superconducting microstrip transmission lines are measured at millimeter and submillimeter wavelengths.

NASA's Jet Propulsion Laboratory, Pasadena, California

Submicron Josephson (superconductor/insulator/superconductor) junctions can be used as both voltage-controlled oscillators and detectors to measure the frequencies (in the range of hundreds of gigahertz) of high-order resonant electromagnetic modes of superconducting microstrip transmission-line resonators. This oscillator/detector approach is similar to that of vacuum-tube grid dip meters and transistor dip meters, which have been used for many years to probe resonances at much lower frequencies.

Measurements of the resonant frequencies of superconducting microstrip resonators are needed both to guide the design of practical submillimeter-wavelength resonators and to understand the physics of these transmission lines. The resonant frequencies and the variations (dispersion) in the frequency intervals between resonant modes are directly related to the attenuation, phase velocity, and characteristic impedance of a transmission line. At lower frequencies, a superconducting transmission line is expected to be lossless and nearly dispersionless. As the frequency rises toward and through the superconducting energy-gap frequency $f_g = 2\Delta/h$ (where Δ is the superconductor energy-gap parameter and h is Planck's constant), one expects to see the onset of greater dispersion, with mode spacing decreasing to a minimum at a frequency slightly above f_g. At frequencies well above f_g, one expects the superconductor to behave as a normal metal.

Figure 1 illustrates an Nb/AlO_x/Nb Josephson junction fabricated integrally and electrically in parallel with an Nb/SiO_x/Nb microstrip transmission line. In its voltage-controlled-oscillator function, the junction provides a signal of frequency $f = 2eV/h$, where e is the fundamental unit of electric charge and V is the dc bias voltage across the junction. This signal sets up a standing wave in the resonator formed by the combination of the junction capacitance and the input admittance of the microstrip transmission line. In its detector function, the junction acts as a mixer, responding to the power reflected from the resonator by putting out a dc component (I) of current. The maximum power is reflected at the resonant frequencies. Thus, as the bias voltage (and, thereby, the frequency) is swept, the resulting I-vs.-V curve includes small current steps at the resonant frequencies.

Figure 2 shows data from such measurements taken on a microstrip transmission line 500 μm long and 12 μm wide. The measured f_g was 660 GHz. The mode spacing was nearly uniform at about 85 GHz at lower frequencies and decreased to a minimum of about 50 GHz at a frequency of 730 GHz. These results were in good agreement with the theoretical prediction, according to which the minimum mode spacing should occur at 740 GHz.

This work was done by Hamid H. S. Javadi, William R. McGrath, Bruce Bumble, and Henry G. LeDuc of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 106*** *on the TSP Request Card.*

NPO-18905

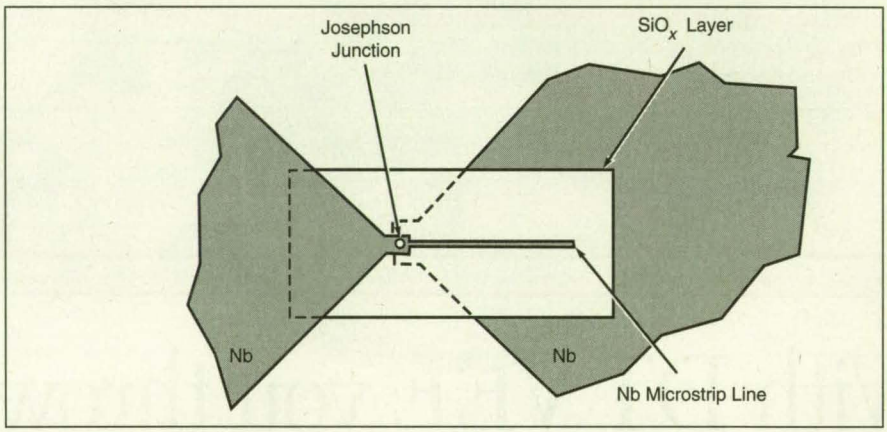


Figure 1. The **Josephson Junction** acts as a voltage-controlled oscillator and a mixer (detector). The voltage is varied to sweep the frequency through resonances, which are detected as steps in the dc component of the current-vs.-voltage response.

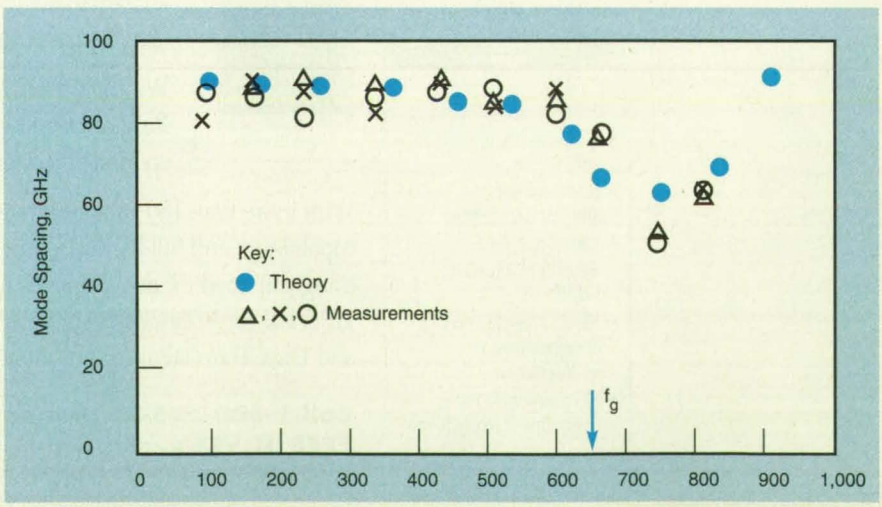
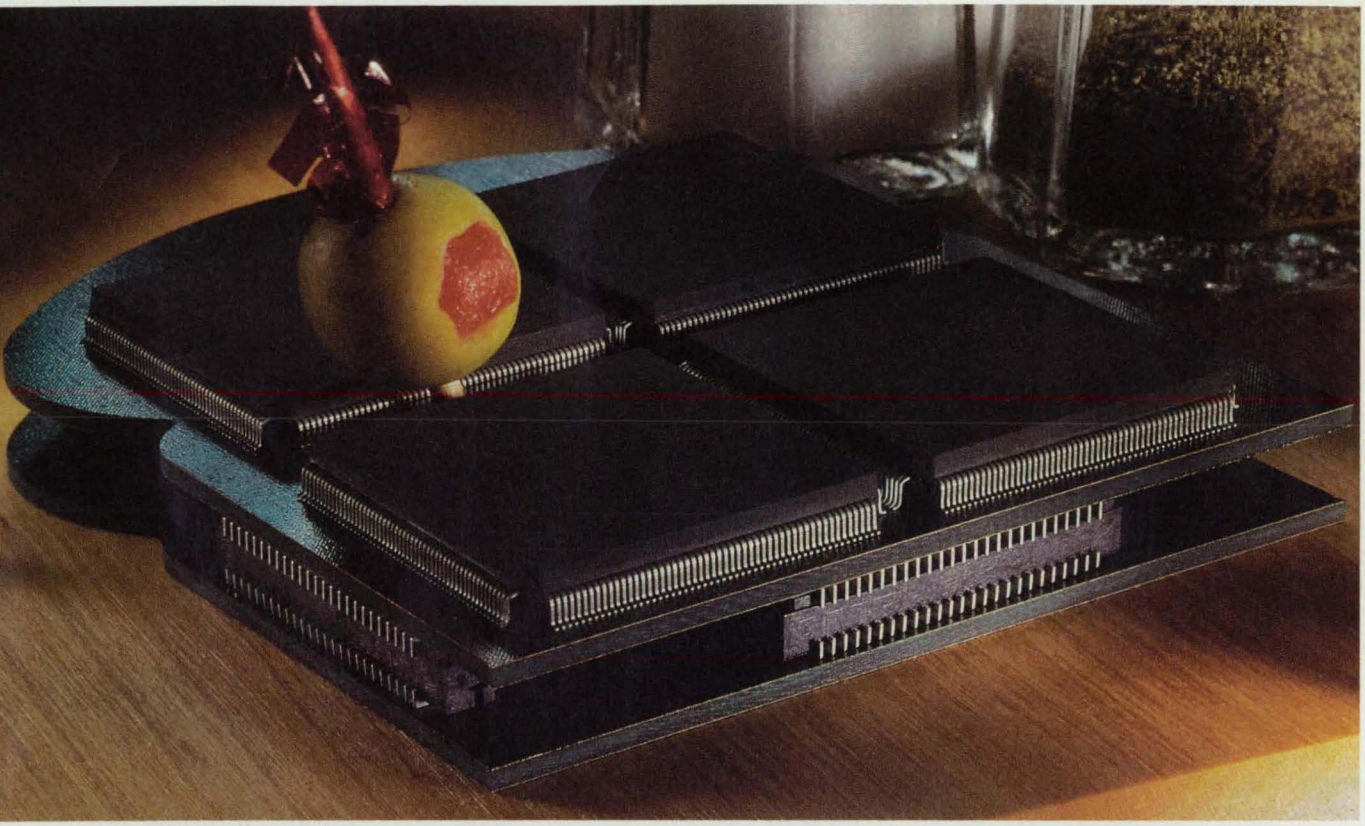
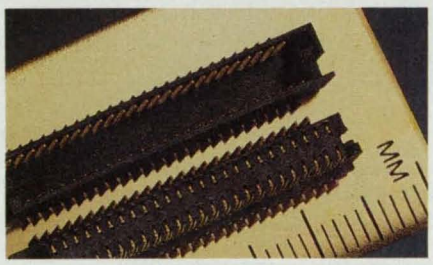


Figure 2. **Dispersion** is manifest at frequencies near f_g (about 660 GHz).

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For More Information Write In No. 662

AMP

Hermetic Packages for Millimeter-Wave Circuits

Signals would be coupled into and out of the packages electromagnetically.

NASA's Jet Propulsion Laboratory, Pasadena, California

Advanced hermetic packages are being developed to house electronic circuits that operate at frequencies from 1 to 100 gigahertz and beyond. Signals would be transferred into and out of such a package by electromagnetic coupling via apertures in the structural base of the package. The heart of the package is the structural base. It provides the mechanical support for the multilayer dielectrics and active devices. It also incorporates the means to employ a physical interconnection to the external environment via combination of waveguide-to-planar and planar-to-planar transmission line types. The dielectric layers and the apertures in them would be configured to provide low-loss electromagnetic coupling with transmission-line, waveguide, and/or transition structures outside the package (see figure).

The basic goal of this development effort is to provide circuit packages that are small, lightweight, rugged, and inexpensive in mass production. Most likely, these packages would be embedded in planar microstrip and coplanar waveguide circuits, in waveguide-to-planar and planar-to-waveguide circuitry, in waveguide-to-waveguide circuitry, between radiating (antenna) elements, and between planar transmission lines and radiating elements. Other applications in automotive, communication, radar, remote sensing, and biomedical electronic systems are also foreseen.

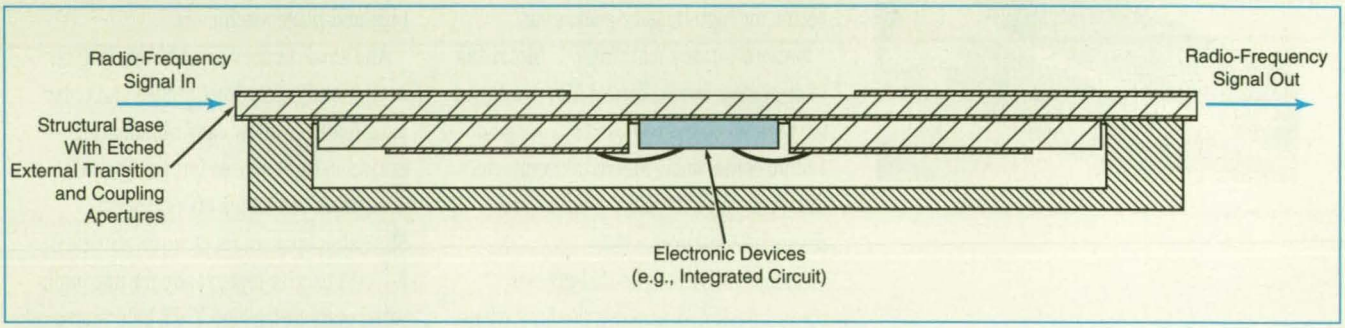
The variety of potential applications, electromagnetic-coupling configurations, packaging materials, and techniques of fabrication together presents the designer with an impressive array of both design requirements and opportunities to satisfy those requirements. The structural base of a package is of primary interest in this regard because it would provide not only electromagnetic coupling as mentioned above but also structural support (as its name suggests) and thermal management (e.g., heat sinking) for the circuitry within the package. Thus, the considerations that would affect the design of the structural base include (but are not limited to) the thermal conductivities and coefficients of thermal expansion of the metal, dielectric, and packaging materials, the electrical parameters of these materials at the intended operating frequency, the position of the package relative to external circuitry, mechanical characteristics, and, of course, the electromagnetic-coupling requirements.

Numerous challenges and opportunities also arise with regard to the interior of the package. For example, the advanced packaging concept is amenable to the packaging of multilayer circuits, incorporation of resonator structures (e.g., cavities), efficient coupling to a single device (e.g., transistor or diode), efficient coupling to a single integrated-circuit chip, and efficient coupling to a multiple-chip module. Low-frequency, digital, and optoelectronic circuitry could be placed in the package to handle control and data signals.

A typical hermetic outer housing would consist of side walls and a lid. The side walls could comprise a solid ring of metal or dielectric (with or without metal coating). Direct-current and/or radio-frequency feedthroughs could be incorporated into the side walls. Windows for optical coupling (e.g., for control signals) could also be incorporated into the lid or side walls.

This work was done by Martin I. Herman, Karen A. Lee, Lynn E. Lowry, Alain Carpenter, and Paul Wamhof of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 91*** *on the TSP Request Card.*

NPO-19094



Signals Would Be Coupled Electromagnetically between external circuits and electronic devices in the package.

Improved Micromachined Transducers

Features would include autonomous commanded calibration, monitoring, and adjustment during operation, and protection when nonoperational.

NASA's Jet Propulsion Laboratory, Pasadena, California

Sensor systems of a proposed type would incorporate (1) micromachined silicon-based structures as electrostatic force and displacement actuators and (2) micromachined quantum-mechanical-tunneling electrodes as one form of displacement transducers, along with electronic circuits that would provide multiple electrical stimuli to the displacement electrodes for measurement, calibration, monitoring of sensor status, and adjustment. The concept is potentially applicable to accelerometers, seismometers, geophones, magnetometers, pressure gauges, and other sensors in which the phenomena of in-

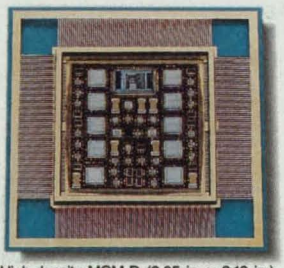
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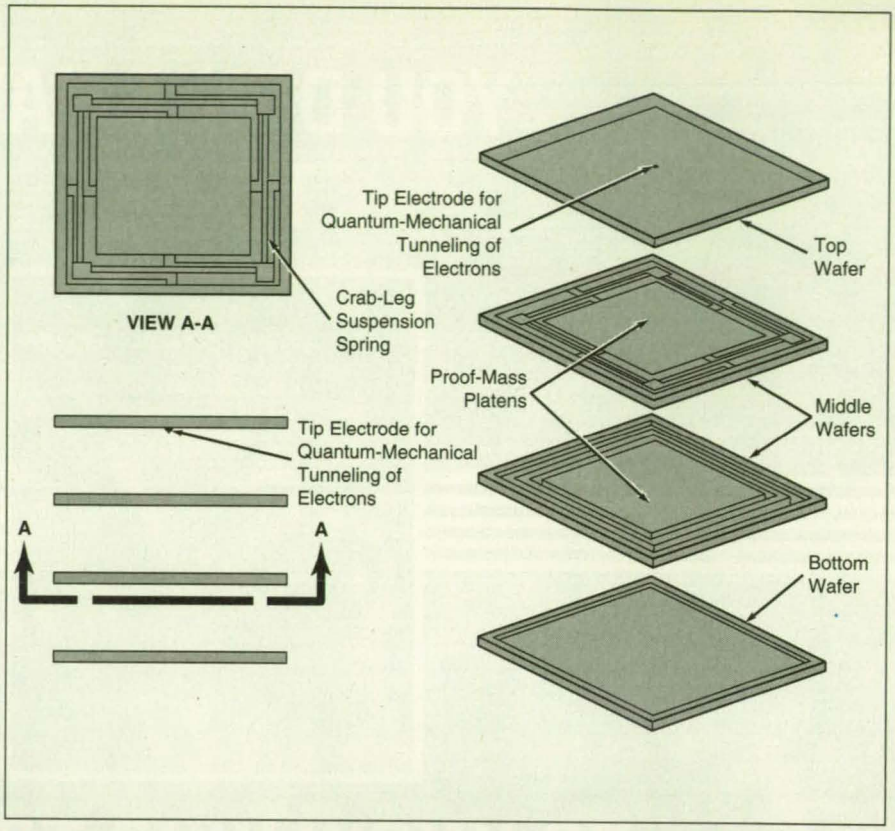
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terest can be measured in terms of forces on, and/or displacements of, the structural components. This concept has the advantage of providing completely remote measurement, control, health monitoring, treatment, and the like, using telemetry commands.

Differential movements are sensed and amplified to generate feedback voltages, which are applied to the electrostatic (in this case) or piezoelectric (in other cases) actuator electrodes to maintain the tunneling electrodes at specified separations. The amplitudes of the instantaneous feedback signals needed to restore the electrodes to the specified separations are indicative of the quantities to be measured.

An important advantage of micromachined sensors is that submicron-thick layers of insulation could be fabricated. Voltages applied to electrodes on opposite faces of such layers would produce large electric fields. Thus, a small single cell of a volt or so could create a large attractive force between two microstructured electrode platens. With a good insulator, the leakage current would be trivial, enabling maintenance of force during a cell life of about a decade.

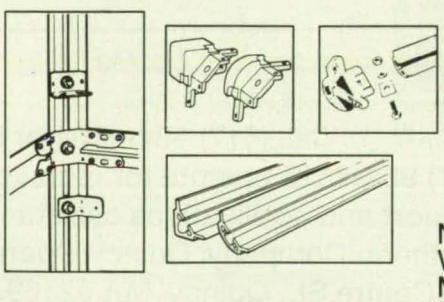
In a microstructured accelerometer, electrostatic retention according to this con-

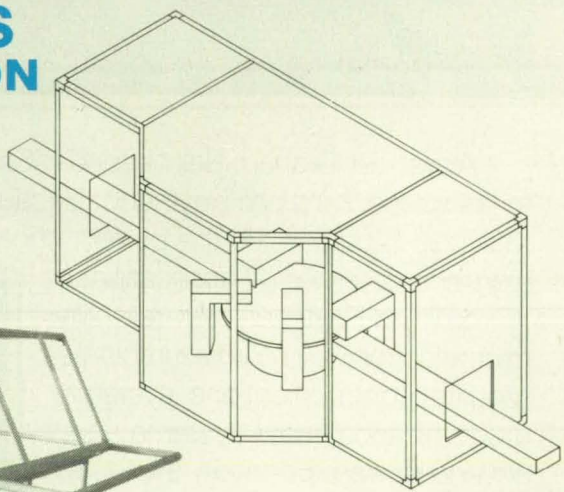


An **Accelerometer** would be made of thin micromachined silicon wafers with integral springs and with electrode platens and other conductors deposited on the wafers.

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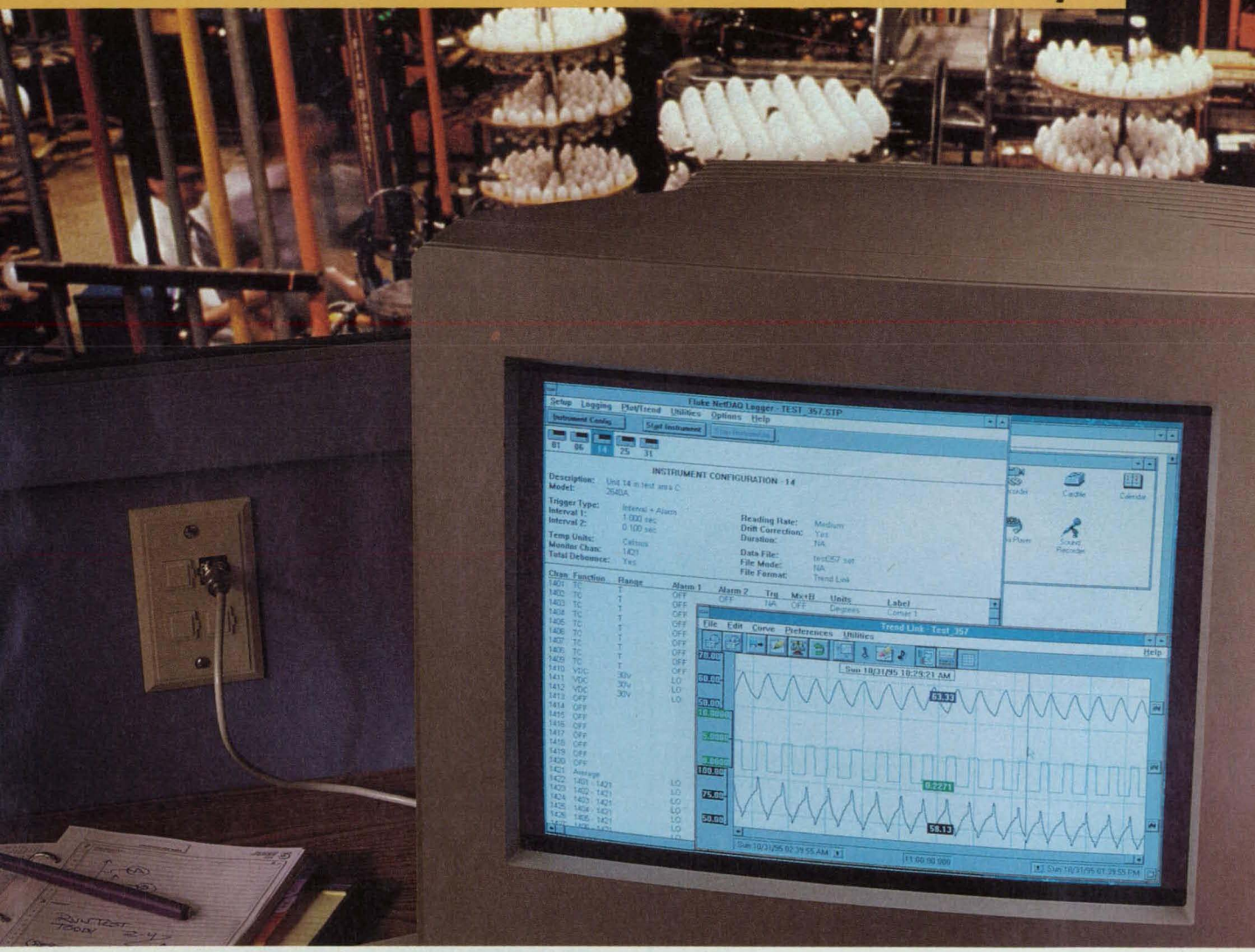
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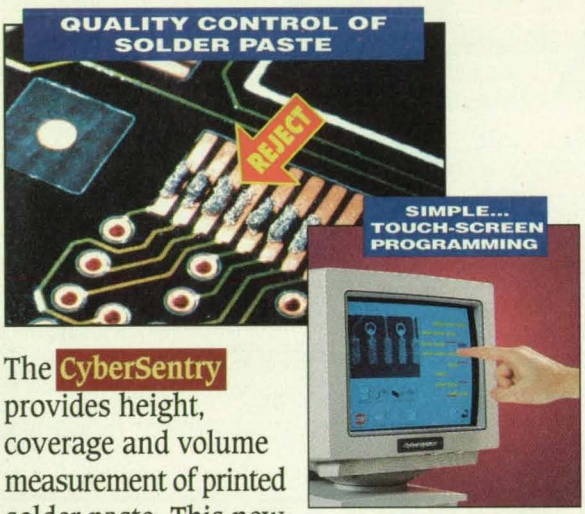
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cept (see figure) would facilitate caging a proof mass to withstand accelerations in excess of 50 times normal gravitational acceleration at the surface of the Earth. Purely mechanical devices with such a capability would at best be exorbitantly complicated. The proof mass would be caged by means of a battery, a simple transistor switch, and a thin layer of insulation separating a proof-mass platen from a parking platen. In addition, the electrical bias could counteract not only a constant external field but also an independently measured or generated varying field. Cancellation of forces could then be executed within a sensor rather than external to it, such as where compensation is needed to offset seismic accelerations for measurements of microgravitational accelerations.

The purely electrical calibration of a sensor of the proposed type (without stimulating the sensor with the quantity or phenomenon to be measured) would be based on the known relationship between that phenomenon and the force that it exerts on the sensor/actuator structure and the known electrostatic force exerted by a known voltage applied to the electrodes in the actuator. These relationships are thermally and temporally invariant; once established, they could be used to apply calibrating actuator signals equivalent to known levels of the phenomenon to be measured. The response of a sensor to such calibrating signals could be analyzed to determine the operational status of the sensor, to determine frequency response and the thermal and aging characteristics of the sensor, and to compensate digitally for drift in bias and other errors in the measurement.

A continuous, nominally fixed (except for drift with age) electrostatic bias would provide an offset, about which an amplified sensitivity scaling or coefficient of response could be established. A fixed bias could be used in characterizing the static response of a sensor by, for example, supporting a sensor element in a fixed gravitational field. This bias technique might be extended to dynamic characterization of a sensor in which alternating voltages of various frequencies and amplitudes would be applied. The potential for such a direct coupling would eliminate the nonlinearities and/or phase lags generally associated with external excitation and enable the precise excitation of ultrasensitive devices.

To alternate measurement with calibration and monitoring of status repeatedly during operation, it would be necessary to time-multiplex (1) the calibration-and-monitoring stimulus voltages, the normal operating bias + feedback voltage, and a zero-bias voltage applied to the actuator electrodes and (2) the tunneling-current responses to these voltages. The measurement bandwidth should be N times the bandwidth of the quantity to be measured, where N is the total number of all multiplexed stimuli (including the normal bias plus feedback). The filtered-step-response transfer function for each stimulus must be determined for use in digital correction of the measurement. The aggregated results of the digital processing of responses to these stimuli would provide for automation of the sensor operation with repeated calibration and compensation for changes in offsets and for changes in coefficients of response.

This work was done by Frank T. Hartley and James H. Wise of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 69*** *on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

William T. Callaghan, Manager
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Improved Writing-Conductor Designs for Magnetic Memory

Writing currents could be reduced to practical levels.

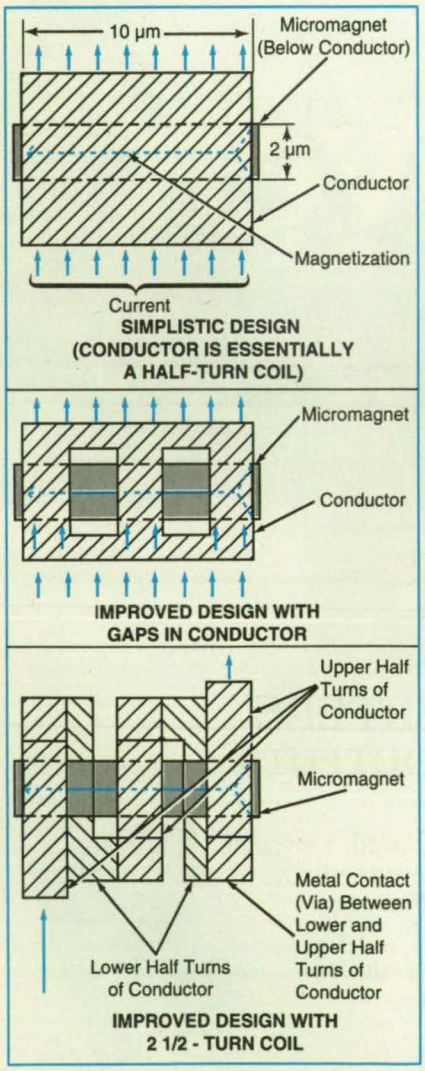
NASA'a Jet Propulsion Laboratory. Pasadena, California

Improved conceptual designs for the writing conductors in a micromagnet/Hall-effect random-access integrated-circuit memory would reduce the electrical current needed to magnetize the micromagnet in each memory cell. These improvements are important for further development of memories of this type because the writing currents needed in simplistic prior designs are too large to be handled conveniently by modest-sized transistors that would normally be used in such memories.

The basic concept of the micromagnet/Hall-effect random-access memory was presented in "Magnetic Analog Random-Access Memory" (NPO-17999), *NASA Tech Briefs*, Vol. 15, No. 11 (November 1991), page 30. As described in more detail in that article, each memory cell according to the simplistic design concept would include an essentially planar strip of ferromagnetic or ferrimagnetic material (the micromagnet that serves as the storage element) and a simple, essentially planar conductor strip separated by a thin layer of insulating material. The current in the conductor would induce a magnetic field substantially in the plane. The magnetomotive force would be proportional to the current density (current per unit width) in the conductor. The top part of the figure is a schematic illustration of the writing conductor and micromagnet in a typical simplistic design.

The middle part of the figure shows an improved design in which gaps would be introduced into the conductor to concentrate the current into narrow strips, beneath which the magnetomotive force would be greater in proportion to the increase in current density as long as the spacing between the conductor and the magnetic material is thin compared to the thickness of the conductor. Provided that the width of the gaps is much greater than the thickness of the insulating layer between the conductor and the micromagnet, and assuming that the magnetic material is highly permeable, the current needed to magnetize to the same degree as in the equivalent simplistic design would be approximately proportional to the ratio between (1) the total width of the remaining conducting strips and (2) the original width of the simplistic conductor. Given the dimensions shown in the figure, about half the current would be needed.

The lower part of the figure shows another improved design that reduces the needed magnetizing current to one twenty-fifth that of the simplistic design. The width of the conductive strip would be reduced to one-fifth the width of the simplistic design, thereby multiplying the current density and the local magnetomotive force by 5. To multiply the magnetomotive force by another factor of 5 (thereby obtaining an overall multiplication of 25), the conductor would, in effect, be wrapped around the micromagnet in a 2½-turn coil. Of course, this would necessitate an additional layer of metal below the micromagnet and additional integrated-circuit-fabrication steps to form the lower half turns of the coil.



The **Improved Designs** would reduce the amount of current (*I*) needed to magnetize the micromagnet.

This work was done by Jiin-chuan Wu, Henry L. Stadler, and Romney R. Katti of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information,* ***write in 35*** *on the TSP Request Card.*

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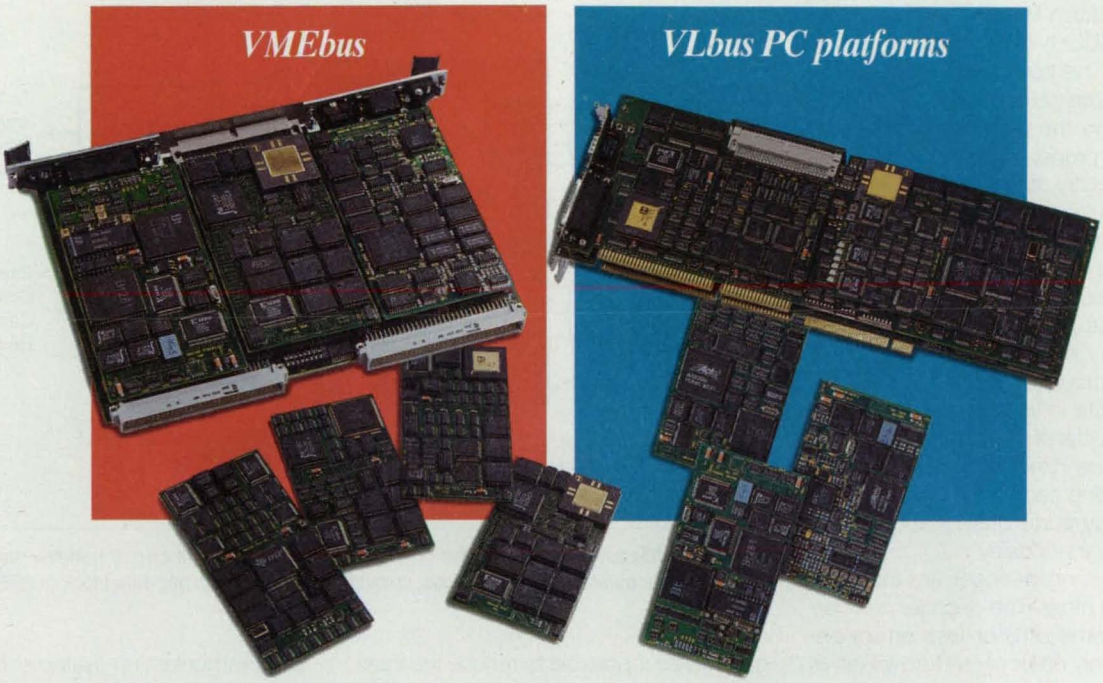
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Triple-Error-Correcting Codec ASIC

This circuit can handle data at rates as high as 300 Mbps.

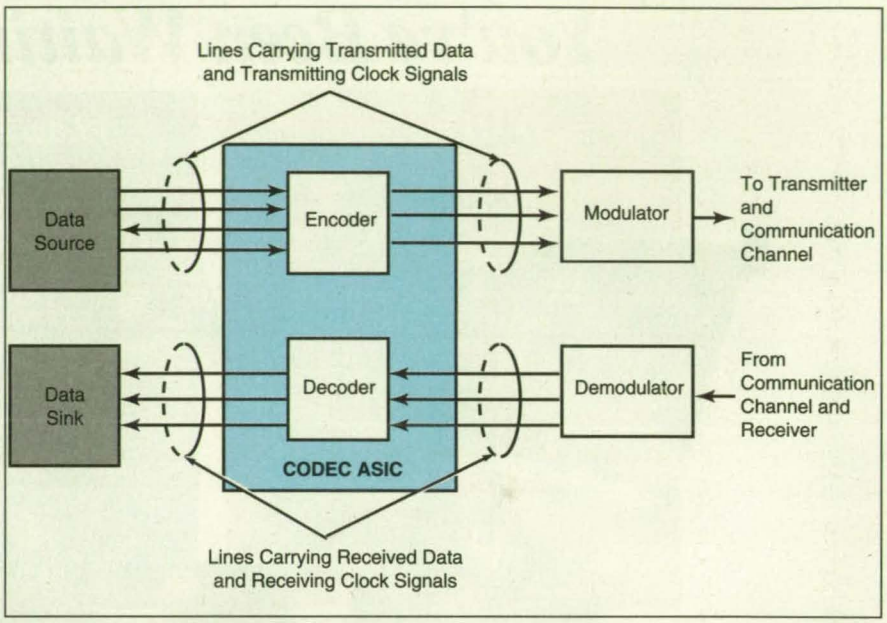
Lewis Research Center, Cleveland, Ohio

The figure illustrates the major functional blocks of a coder/decoder (codec) application-specific integrated circuit (ASIC) that implements a Bose–Chaudhuri–Hocquenghem (BCH) triple error correcting block code. This codec can handle digital signals at data rates up to 300 Mbps, depending on the particular modulation format (with proper external data-formatting logic circuitry, it can be used with any type of modulation).

The ASIC features a low-power complementary metal oxide/semiconductor standard cell design containing about 18,000 equivalent gates. It is mounted in a 132-lead pin-grid-array package. It includes flexible interface circuitry that can be configured to accept data in widths of 1, 2, 4, or 8 bits and in blocks of varying total sizes from 256 to 512 bits in increments of 16 bits. In addition, coding can be turned on and off on a burst-by-burst basis without altering the throughput delay.

The coder and decoder are independent of each other. The decoder can correct all patterns of 3 or less errors per block. The only other circuit known (as of 1992) to be competitive and commercially available is limited to a data rate of 30 Mbps and to correction of no more than 2 errors in a codeword that has a fixed size of 511 bits.

This codec can provide up to 4 dB of coding gain without soft decision information at a bit-error rate of 10^{-8} at code rates from 7/8 to 15/16. The high code rates help to conserve bandwidth, while the coding gain makes it possible to reduce the transmitter power or the gain of the transmitting or receiving antenna by a factor of about 2 while maintaining performance at the level attainable at full power or gain without the codec. Thus, the codec can help to reduce the cost of transmitting data. It could be useful in many high-data-rate, bandwidth-limited communication systems; for example, personal communication networks, cellular telephone networks, satellite communication systems, high-speed computing networks, broadcasting, and high-reliability data-communication links.



The **Coder/Decoder** is constructed on a single integrated-circuit chip. It handles data in a variety of formats at rates up to 300 Mbps, correcting up to 3 errors per data block of 256 to 512 bits

This work was done by Robert E. Jones of **Lewis Research Center** *and Greg P. Segallis and Robert Boyd of Harris Corp. For further information,* ***write in 10*** *on the TSP Request Card.*

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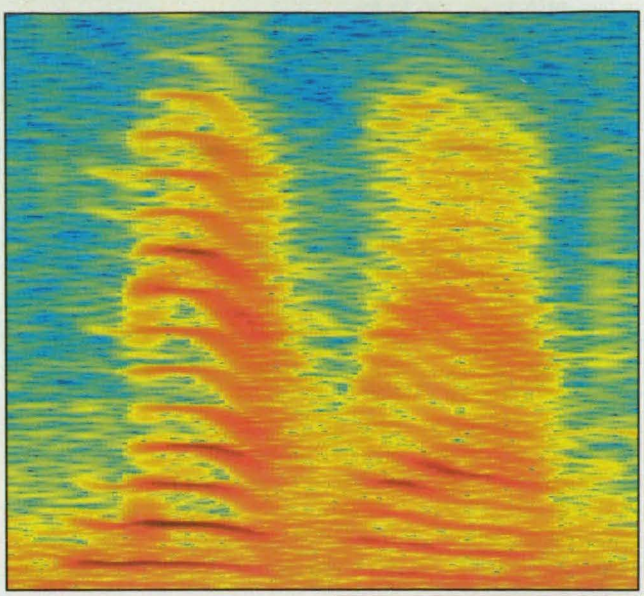
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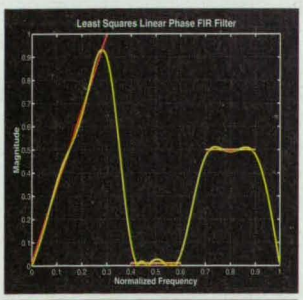
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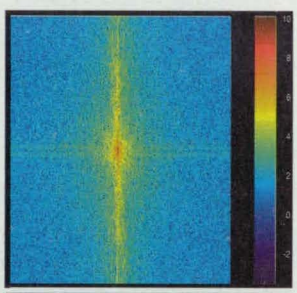
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For More Information Write In No. 665

Single-Barrier-Varactor 200-GHz Tripler

Overall efficiency of 2 percent has been achieved.

NASA's Jet Propulsion Laboratory, Pasadena, California

A single-barrier varactor in a crossed waveguide serves as an experimental frequency-tripling device with output at frequencies ranging from 186 to 207 GHz (the corresponding input frequencies are 62 to 69 GHz). The primary reason for choosing a single-barrier varactor instead of another nonlinear device (e.g., a Schottky varactor) is that unlike the other devices, the single-barrier varactor has a symmetrical capacitance-vs.-voltage characteristic and an antisymmetrical zero-frequency current-vs.-voltage characteristic. One important consequence of these characteristics is that only odd harmonics are generated when the varactor is operated at zero dc bias: this is advantageous in that adequate efficiency is achievable with a simpler tripler design because there is no need to incorporate adjustable terminations that are reactive at the even-harmonic frequencies into the varactor mount to reduce losses at these frequencies.

Figure 1 illustrates the single-barrier varactor and its electrical characteristics. The top and bottom contact layers, formed on highly doped GaAs regions (dopant density = 3.4×10^{18} cm^{-3}), are AuGe 1,000 Å thick, Ni 200 Å thick, and Au 1,600 Å thick. The top contact is made with a whisker, and the bottom contact is a large-area ohmic contact. The conduction current through the varactor is blocked by the $Al_{0.7}Ga_{0.3}As$ barrier.

Thermionic emission is the primary cause of the conduction current at moderate voltages. A variation in bias voltage changes the width of the depleted part of the moderately doped epitaxial layer, thereby forming a voltage-dependent capacitance. The minimum capacitance, determined by the concentration of dopant and the width of the moderately doped drift region, is obtained at maximum bias voltage. The maximum capacitance, determined by the thickness of the $Al_{0.7}Ga_{0.3}As$ barrier, is obtained at zero bias voltage. An appropriate design is expected to yield a capacitance-vs.-voltage characteristic similar to that of a Schottky varactor diode in reverse bias. The radio-frequency current is maximum at zero bias because the capacitance is maximum there. At zero bias, the drift regions on both sides of the barrier are undepleted. Thus, this varactor exhibits larger losses attributable to dynamic series resistance than do Schottky varactors.

The embedding impedances needed to optimize the performance of the single-barrier varactor as a tripler are 7 to 30 Ω resistive, 40 to 100 Ω reactive in the input circuit, and 15 to 42 Ω reactive in the output circuit. These impedances are provided by the crossed-waveguide mount, wherein the varactor is mounted across the output waveguide. In Figure 2, the output waveguide is shown schematically parallel to the input waveguide, but in a more realistic rendering it would be oriented perpendicular to the page. The output waveguide has reduced height (0.99 mm), and a transition to a full-height WR4 waveguide is integrated into the mount.

The fundamental-frequency pump (input) power is fed to the varactor via a low-pass filter that consists of a pattern of gold 2 μm thick on a quartz substrate 76.2 μm thick and 0.71 mm wide. An electric-field-plane tuner and a backshort in the input waveguide are used to make adjustments to optimize the input embed-

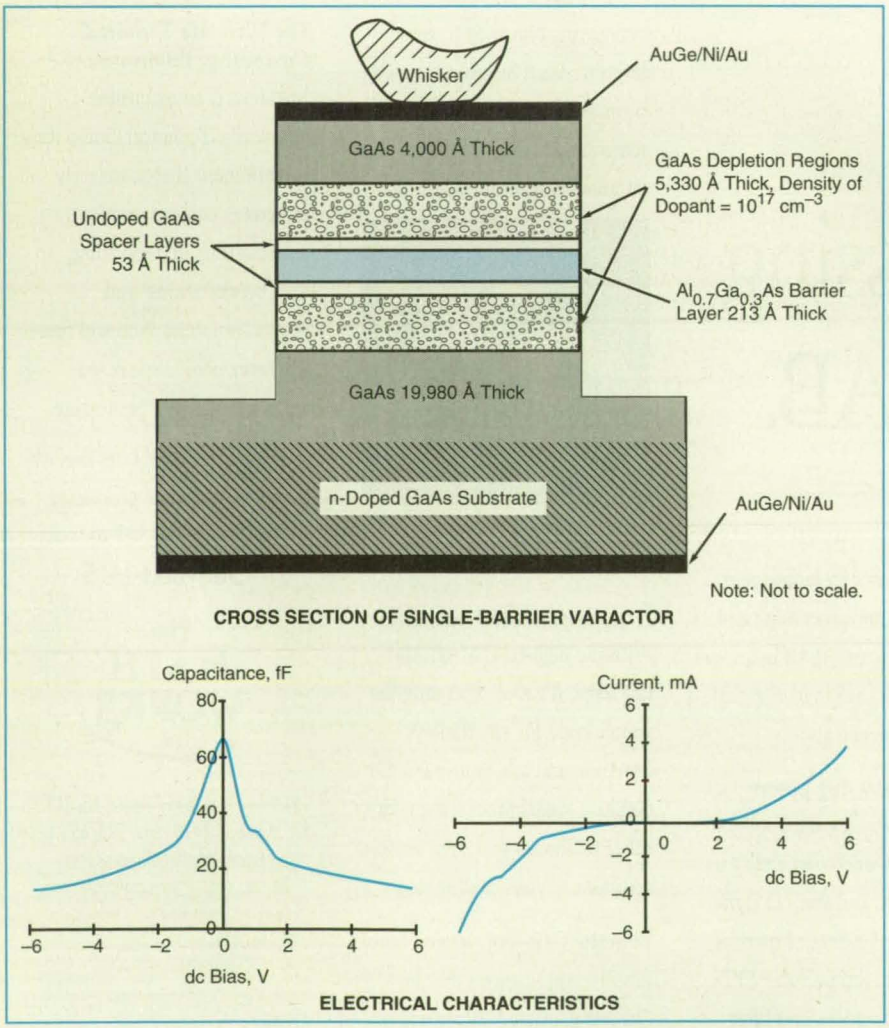
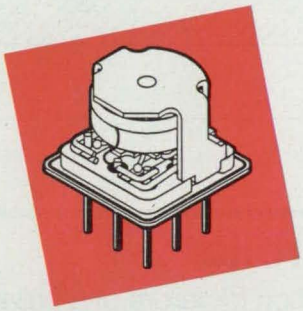


Figure 1. The **Single-Barrier Varactor** has a symmetrical capacitance-vs.-voltage characteristic and an antisymmetrical dc current-vs.-voltage characteristic. As a result, this varactor generates only odd-harmonic currents when a radio-frequency voltage is applied at zero dc bias.

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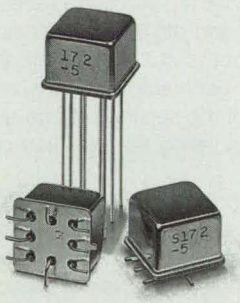
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ding impedance. The dimensions of the output waveguide are chosen so that the input frequency is below its lower cutoff frequency. The embedding impedance at the output frequency is adjusted by varying the length of the whisker and by moving a backshort in the output waveguide.

In tests, the tripling efficiency as measured at the input and output waveguide flanges of the mount was found to be about 2 percent. Accounting for losses in the mount, the tripling efficiency of the varactor alone was about 5 percent. This level of performance is comparable to that of a standard Schottky-varactor tripler. Performance could be improved by reducing losses.

This work was done by Debabani Choudhury, Margaret A. Frerking, and Paul D. Batelaan of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 107*** *on the TSP Request Card.*
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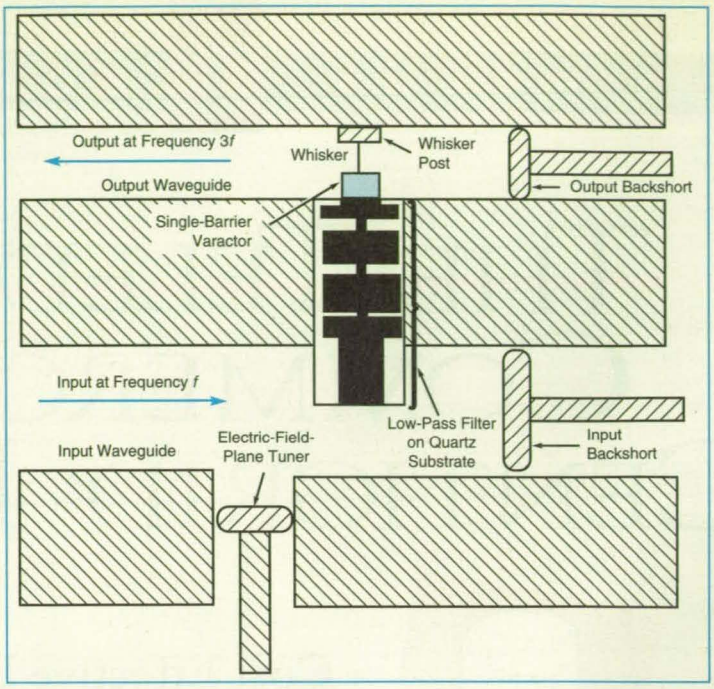


Figure 2. The **Frequency Tripler** consists of the single-barrier varactor in a crossed-waveguide mount. This illustration is only schematic: The output waveguide is oriented perpendicular to the input waveguide.

Discrete/PWM Ballast-Resistor Controller

This circuit offers low switching loss and automatic compensation for failure of a ballast resistor.

Lewis Research Center, Cleveland, Ohio

The discrete/PWM ballast-resistor controller is an improved shunt voltage-regulator circuit designed to supply power from a high-resistance source (e.g., a thermoelectric converter or a solar photovoltaic battery) to a low-impedance bus. As its name implies, the design of this circuit incorporates features of both (1) the discrete method of control, in which steady-state bus voltage is controlled by switching ballast resistors into or out of the circuit and (2) the pulse-width-modulation (PWM) method of control, in which pulses of current from the source are repeatedly switched on and off, a capacitor across the bus smooths out the ripples in the voltage thus generated, and the steady component of the rippling voltage is controlled by regulating the duration of the pulses.

Discrete control involves no switching loss in the steady state, but provides only discrete increments of voltage at relatively high bus impedance and is not suitable for transient operation. PWM control can satisfy voltage-regulation tolerances much smaller than the increments of discrete control, and can respond to transients, but involves large switching losses and necessitates a large capacitor to suppress ripple. In the discrete/PWM control ballast-resistor controller, the discrete method can be regarded as providing the coarse voltage adjustment, while the PWM

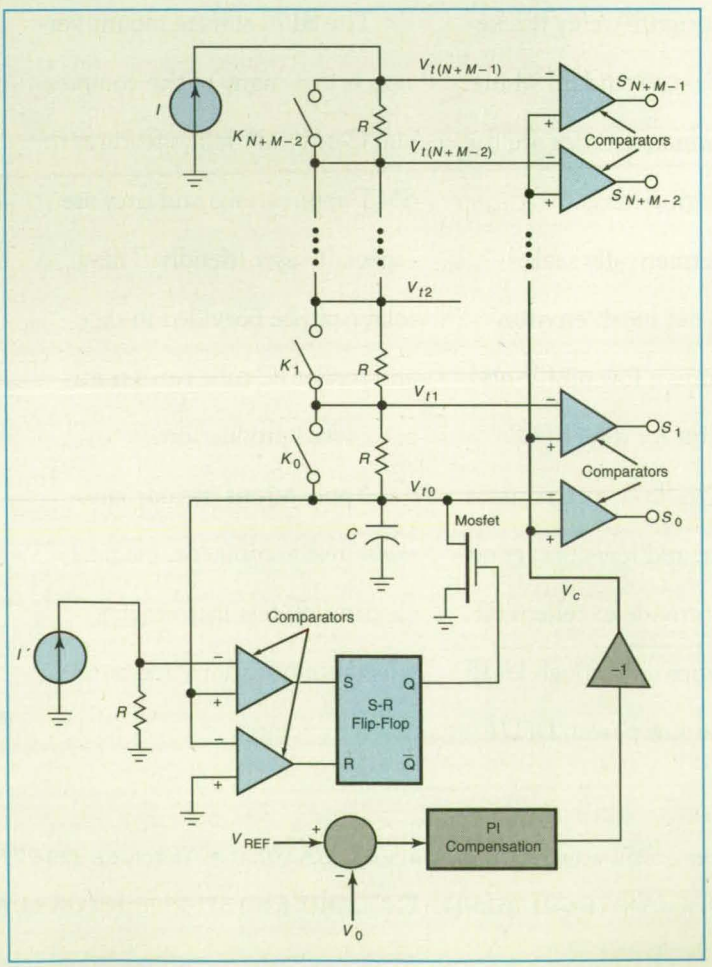
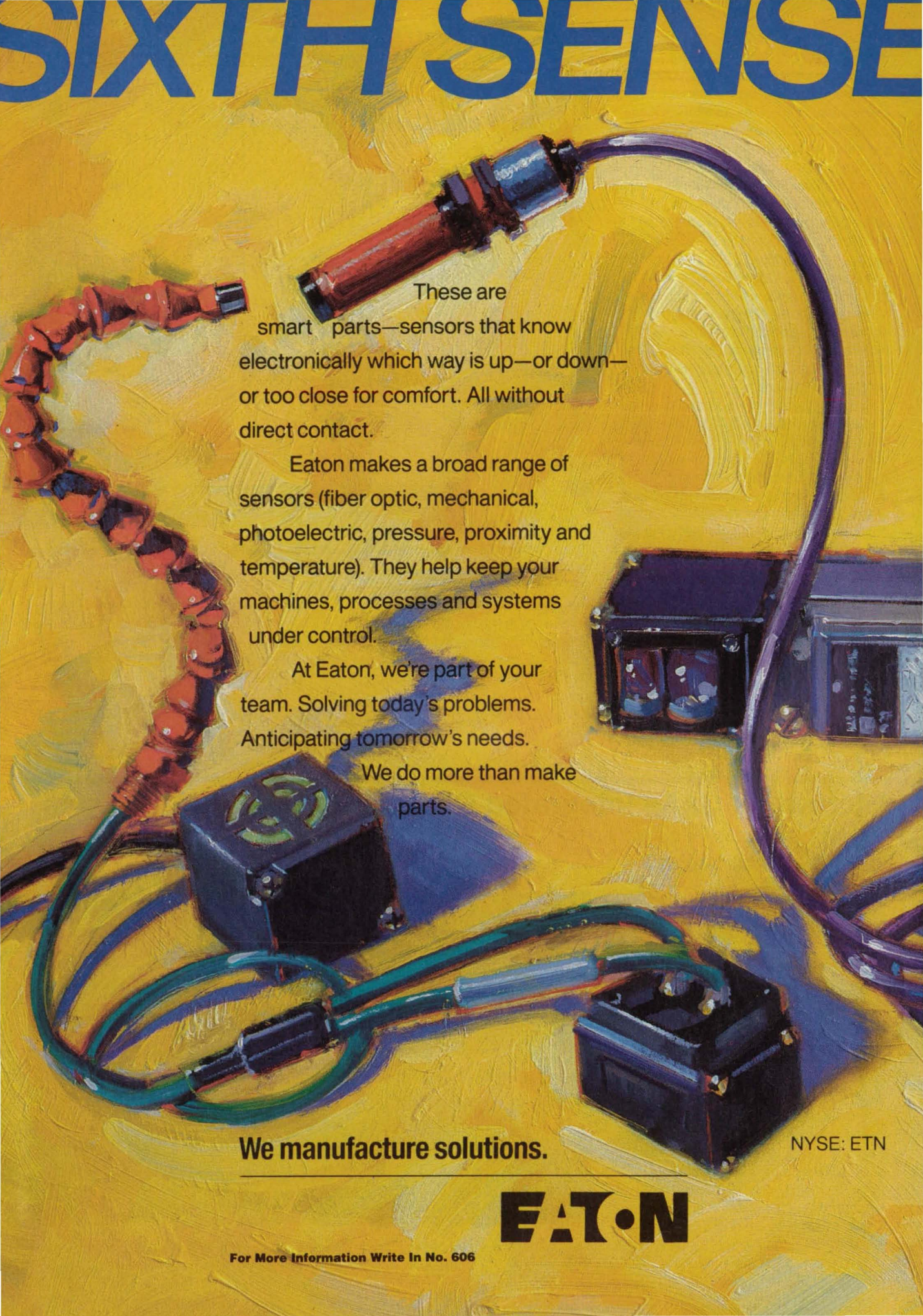


Figure 1. The **Discrete/PWM Ballast-Resistor Controller** provides both coarse discrete voltage levels (by switching of ballast resistors) and continuous fine control of voltage via pulse-width modulation.

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method can be regarded as providing the fine voltage adjustment. Bus voltage is regulated with low bus impedance and low switching loss. In addition, the discrete/PWM ballast-resistor controller compensates automatically for an open- or short-circuited ballast resistor.

The discrete/PWM ballast-resistor controller contains N normally active plus M spare ballast resistors, each controlled by a corresponding comparator output $S_0 \ldots S_{N+M-1}$ (see Figure 1). The pulse-repetition period is T_S. During each period, current source I' gives rise to a ramp waveform up to a maximum voltage of $I'R$ across the capacitor. Meanwhile, approximately equal current source I gives rise to voltage drops, in increments of IR, across the resistors.

Through the combined actions of the metal oxide semiconductor field-effect transistor (MOSFET), S-R flip-flop, and comparators, the circuit puts out $N + M$ ramp waveforms, each with ramp height $I'R$ and progressive offsets of IR (see Figure 2). The control voltage, v_C falls on only one of the ramps, so that only the corresponding switch operates under PWM control and all the other switches operate under discrete control. In the steady state, only the switch under PWM control exhibits switching losses. In the transient state, all switches can be operated nearly simultaneously.

If no other action is taken, then either an open-circuit failure of a ballast resistor or a short-circuit failure of its switching transistor results in a dead zone in the control action and, in the case of a short circuit, a reduction in available load power. The controller includes circuitry (not shown) that closes one of the switch contacts K_0 through K_{N+M+2} to bypass the failed ballast resistor from the control action.

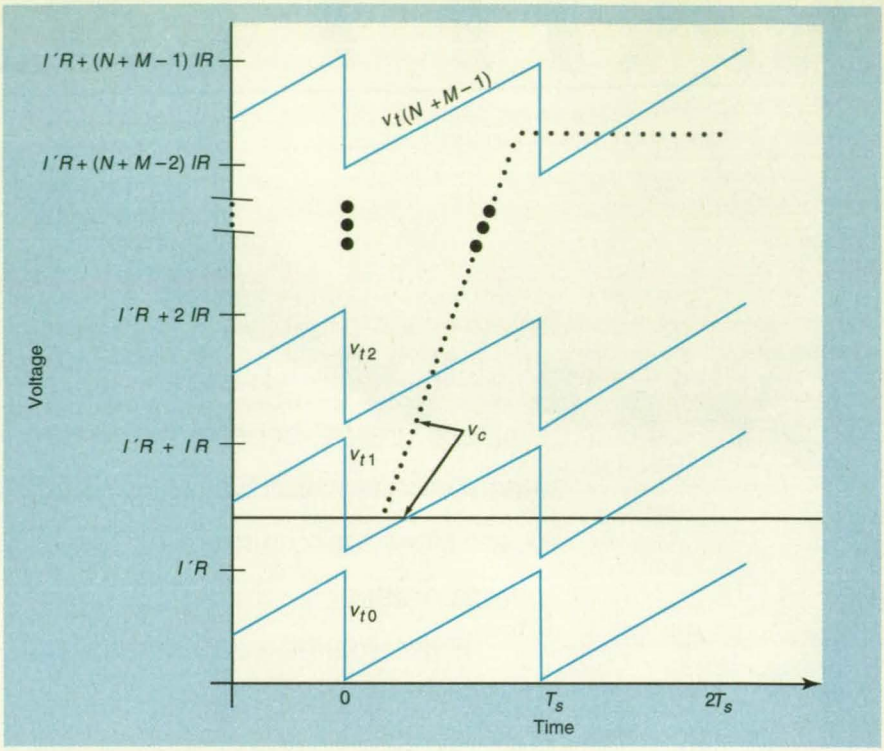


Figure 2. These **Offset Ramp Voltage Waveforms** are generated in the discrete/PWM ballast-resistor controller.

This work was done by Roger J. King of the University of Toledo for **Lewis Research Center**. *For further information,* ***write in 12*** *on the TSP Request Card.*
LEW-15129

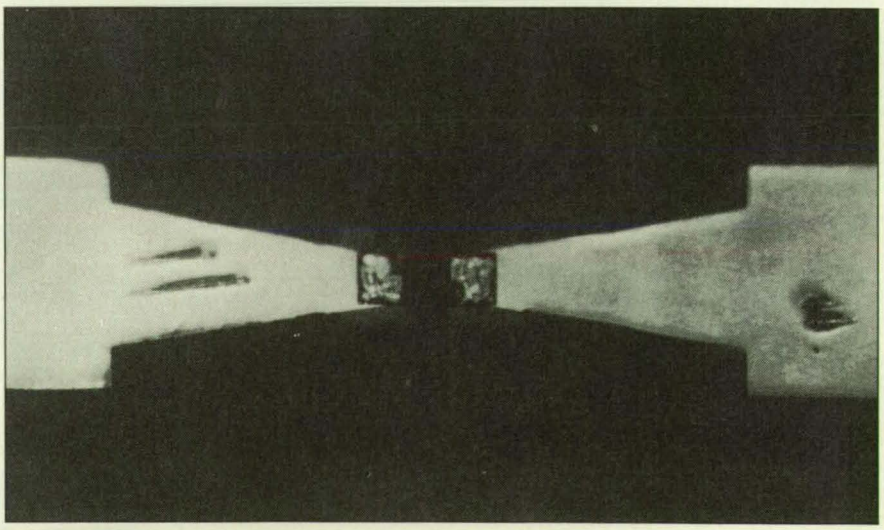
Microwave GaAs Integrated Circuits on Quartz Substrates

Hybrid structures offer combined advantages of both material systems.

NASA's Jet Propulsion Laboratory, Pasadena, California

Integrated circuits for use in detecting electromagnetic radiation at millimeter and submillimeter wavelengths can be constructed by bonding GaAs-based integrated circuits onto quartz-substrate-based stripline circuits. This hybrid approach offers the combined advantages of high-speed semiconductor active devices that can be made only on epitaxially deposited GaAs substrates with low-dielectric-loss, mechanically rugged quartz substrates.

Typically, the GaAs-based integrated circuit in a hybrid circuit of this type is less than 5 μm thick and contains passive and active discrete circuit elements (e.g., transistors, diodes, and resistors), most of which are much smaller than the wavelength at operation; the quartz-based circuit is much thicker and typically includes integrated stripline circuit elements (e.g., antenna



This **Millimeter-Wave Mixer Circuit** includes filters made by the lift-off process, plus a separately mounted GaAs planar diode in a 200-GHz waveguide mount.

elements, transmission lines, low-pass filters) and possibly dielectric lenses, most of which have linear dimensions (except thickness) of the order of the wavelength. By making the GaAs layer much thinner than the wavelength and by keeping it undoped except in the small regions that contain the active devices, one ensures that the microwave electromagnetic field generated by the currents in the stripline circuitry interacts with a dielectric medium that consists primarily of the quartz substrate and is relatively unaffected by the GaAs semiconductor material.

Fabrication begins with the epitaxial deposition of an undoped layer of AlAs, 50 to 75 Å thick, on a GaAs wafer. This layer is subsequently etched away, as explained below following an established 'lift-off' process developed at Bell Laboratories. The GaAs integrated circuit, including all passive and active circuit elements, is fully formed on top of the AlAs layer by use of epitaxial growth, photolithography, and other established techniques. The top surface of the GaAs integrated circuit is coated with black wax dissolved in trichloroethylene, then dried in an oven at a temperature of 160 °C.

To separate the thin integrated circuit from the GaAs wafer, the AlAs layer is etched away in a 10-percent solution of hydrofluoric acid at 0 °C. The black wax is critical to this step in that it places the integrated-circuit layer under slight tension so that it peels up as the etch proceeds inward from the edges of the wafer. When the etch is complete, the thin integrated-circuit layer and wax float off the GaAs wafer and are removed from the solution. The GaAs integrated-circuit layer, still coated with wax, is attached to the quartz integrated circuit, either by proximity bonding or by use of an ultraviolet-cured optical cement. The wax is removed by dissolving it in trichloroethylene. The resulting GaAs/quartz hybrid can then be processed by established techniques of chemical cleaning, dicing, slight heating, and/or bump bonding.

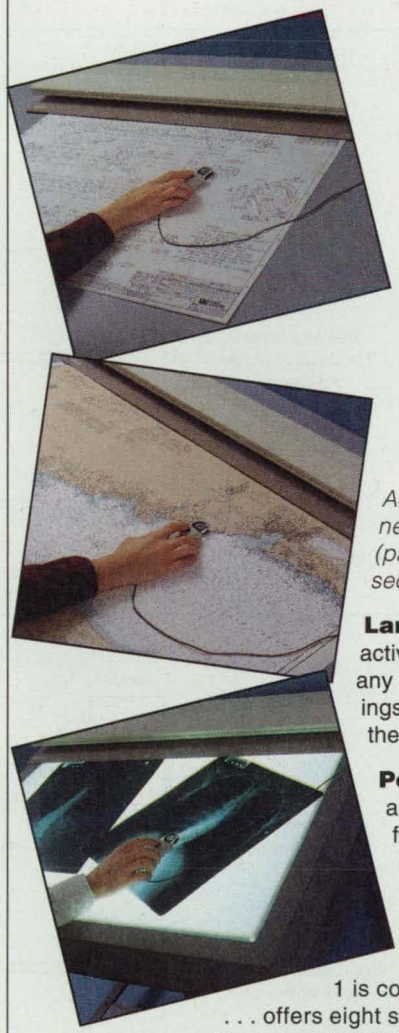
Test hybrid structures that contain low-pass microstrip filters, micro-airbridges, and planar GaAs diodes have been fabricated (see figure). This hybrid approach is also being followed in developing a 640-GHz integrated mixer circuit that includes a pair of planar GaAs diodes in the middle of two GaAs-on-quartz low-pass microstrip filters. Other potential applications include integration of antenna elements with active devices, using carrier substrates other than quartz to meet particular requirements (for example, more-efficient dissipation of heat), using the lifted-off GaAs layer in a membrane configuration with the quartz substrate supporting the edges only, and using the lift-off technique to fabricate ultrathin discrete devices that can be diced separately and inserted into predefined larger circuits. In a different device concept, quartz substrate might be utilized as a transparent support for GaAs devices that would be excited from the back side by optical radiation. This excitation mode would be made possible by the ultrathin GaAs lift-off layer and could not be achieved with a thick, opaque, GaAs substrate.

This work was done by Peter H. Siegel, Imran Mehdi, and Barbara Wilson of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 18*** *on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Refer to NPO-18809, volume and number of this NASA Tech Briefs *issue, and the page number.*



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Improved Separators for Rechargeable Lithium Cells

Pairs of separators would prevent short-circuiting by lithium dendrites.

NASA's Jet Propulsion Laboratory, Pasadena, California

Improved pairs of separators have been proposed for use in rechargeable lithium cells that operate at ambient temperature. In the absence of separators, lithium dendrites can grow from the anodes to the cathodes of such cells, thereby short-circuiting the cells. The proposed separators would block the growth of lithium dendrites and thereby help prevent short circuits. Each cell would contain one separator made of microporous polypropylene placed next to the anode, and one separator made of microporous polytetrafluoroethylene (PTFE) (which reacts chemically with lithium but not with the cell electrolyte) next to the cathode.

By helping to prevent short circuits in cells, the proposed separators could increase the cycle lives of secondary lithium cells. The cells to which this concept is expected to be applicable are those of the Li/TiS_2, $Li/NbSe_3$, Li/CoO_2, Li/MoS_2, Li/VO_x, and Li/MnO_2 chemical systems. Research has shown that the growth of lithium dendrites and the attendant shorting could also be prevented by the use of alternative lithium anodes in which the lithium is not in metallic form, but that the specific energy of an AA-size cell that contains such an alternative anode is only about 65 W•h/kg. In contrast, an AA-size cell that contains the proposed improved separators would exhibit a specific energy of about 120 W•h/kg. Cells of this type could prove advantageous in spacecraft, military, communications, automotive, and other applications in which high energy density and rechargeability are needed.

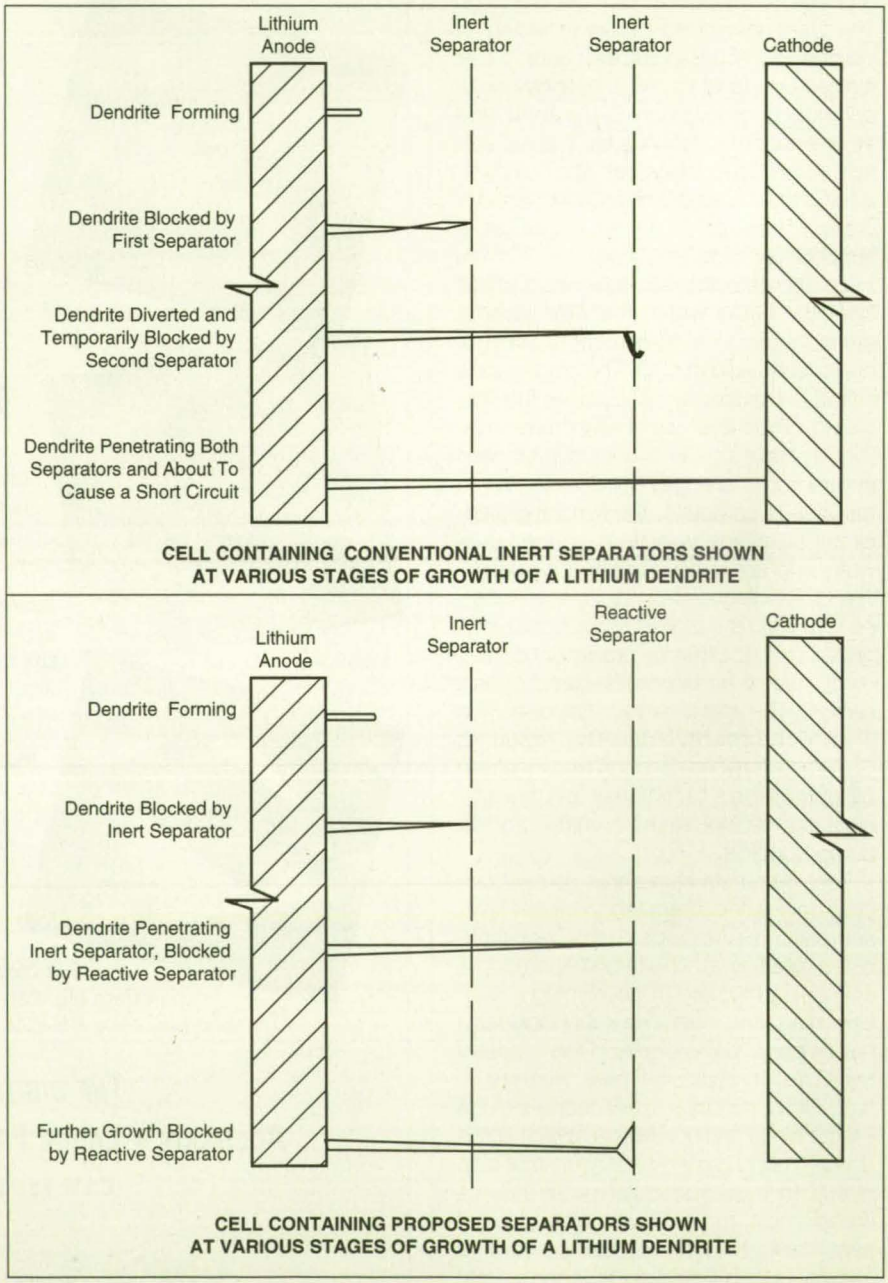
The currently widely used microporous separators of polypropylene and nonwoven glass paper have been found to be incapable of preventing shorting by lithium dendrites during repeated charge/ discharge cycling, as shown at the top of the figure. The state-of-the-art separator in current use is of a thermal-fuse type that includes a wax coat on its surface. When a cell that contains such a separator becomes short-circuited by lithium dendrites, the heat generated by the discharge of the cell through the short circuit melts the wax, blocking the pores in the separator and thus blocking the transport of electrolyte ions and causing the cell to reach an open-circuit condition.

In a cell that contained the proposed separators (see bottom of figure) any growth of a dendrite that was not blocked by the inert polypropylene separator and that reached the PTFE separator would react with the PTFE separator. This reaction would produce only local blockage of pores in the PTFE separator and would thus allow the continued transport of electrolyte ions everywhere else through the PTFE separator. Thus, the cell could continue to function until lithium had reacted with a major portion of the PTFE separator.

This work was done by David Shen, Subbarao Surampudi, Chen-Kuo Huang, and Gerald Halpert of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 70*** *on the TSP Request Card.*

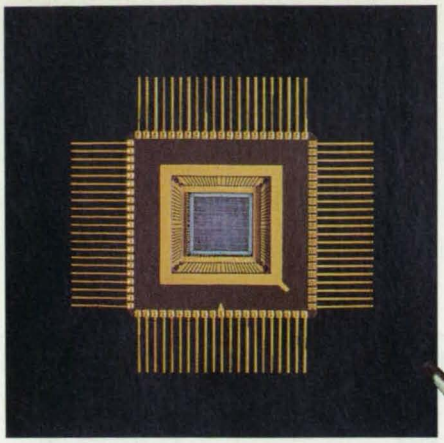
This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office– JPL [see page 20].

Refer to NPO-18585.

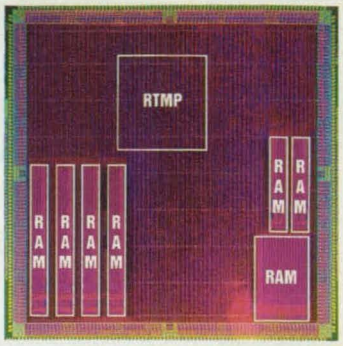


Lithium Dendrites can penetrate conventional separators, causing short circuits, but would be stopped by a reactive PTFE separator.

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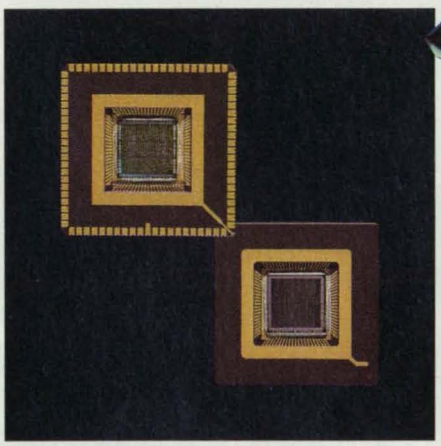
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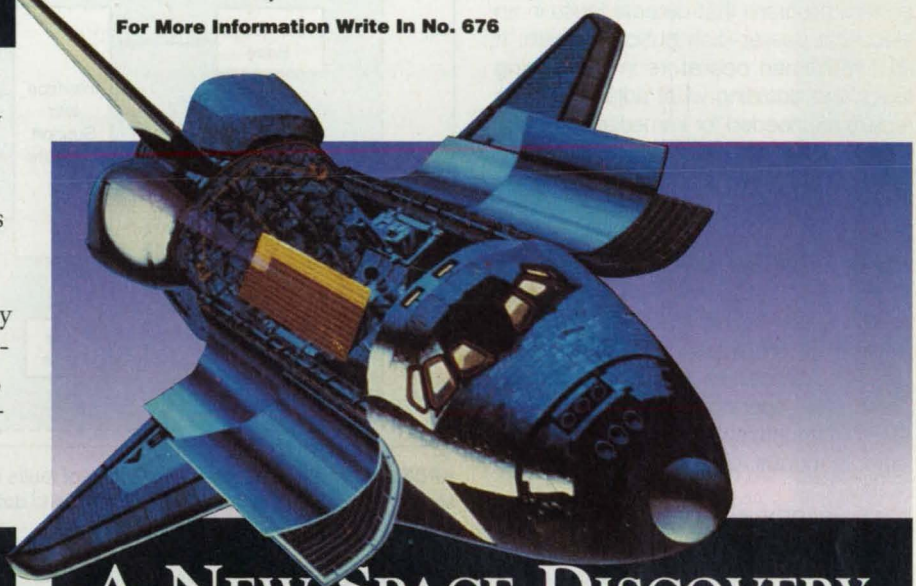
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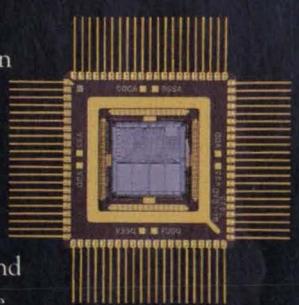
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Expert System Detects Power-Distribution Faults

It assists human operators in monitoring a complex distribution system.

Lewis Research Center, Cleveland, Ohio

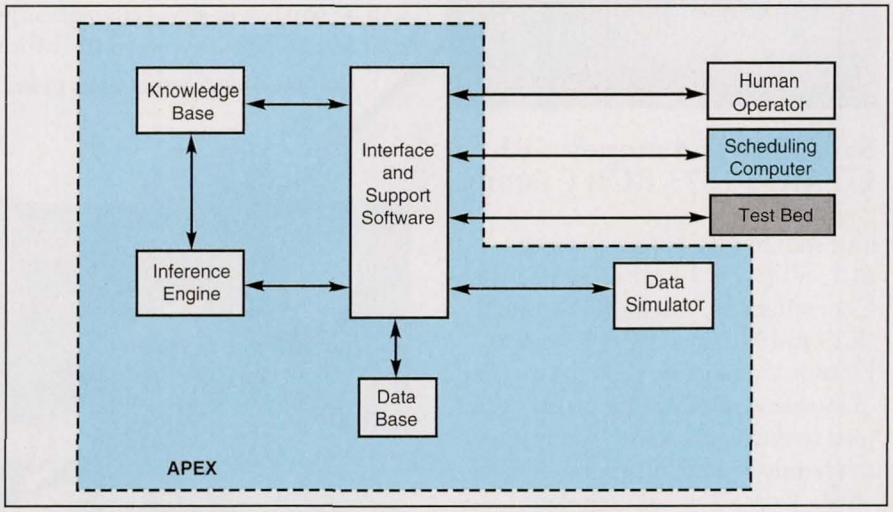
The Autonomous Power Expert (APEX) computer program is a prototype expert-system program that detects faults in an electrical-power-distribution system. It assists human operators in diagnosing faults and deciding what adjustments or repairs are needed for immediate recovery from faults or for maintenance to correct initially nonthreatening conditions that could develop into faults.

APEX is written in the Lisp computing language and installed on a computer workstation that receives data from sensors in a 20-kHz power-distribution test-bed. APEX emulates a human expert's reasoning processes in diagnosing faults. The human operator communicates with APEX in an intuitive way with mouse-selectable menus, color graphics, and text displays.

When APEX detects a fault, it informs the operator, who can direct it to isolate the probable cause. APEX consults a set of isolation rules to determine the probable cause. APEX informs the operator of the probable cause and recommends corrective action to restore the power-distribution system to full operational status.

APEX detects faults by repeatedly comparing measured values of operating parameters with expected values. It calculates the expected values from historical data pertinent to the loads currently connected to the power-distribution system. When it finds an anomaly, it notifies the operator of an actual or incipient fault.

APEX (see figure) includes a knowledge base that contains facts and rules acquired from a human expert. APEX provides a data base, which contains sensory data and the results of calculations based on the data. APEX contains an inference engine, which is the reasoning mechanism that, in the process of diagnosing faults, draws conclusions from information stored in the knowledge base. The inference engine also provides the reasoning capability for choosing appropriate recovery procedures. APEX contains interface and support software that enable it to obtain data from various outside sources. Finally, APEX includes software that simulates data, enabling the testing of APEX when the test-bed is unavailable; this data-simulator software also enables human experts to display actual test-bed data and send commands to control the test-bed.



APEX determines the causes and cures of faults in a power-distribution test-bed. The inference engine reasons on the basis of knowledge and data provided by the other components of APEX.

An external scheduling computer generates source profiles that represent the power resources that will be available during a specified time, and load profiles that indicate how much power the loads will consume during the same time. The scheduling computer also informs APEX of the starting times for the various loads. APEX uses the profiles and load schedules in its calculations of expected values.

This work was done by Jerry L. Walters of **Lewis Research Center** *and Todd M. Quinn of Sverdrup Technology, Inc. For further information* ***write in 41*** *on the TSP Request Card.*

LEW-15673

Anticipatory Neurofuzzy Control

This adaptive technique is suitable for controlling poorly modeled systems.

Marshall Space Flight Center, Alabama

A technique of feedback control, called "anticipatory neurofuzzy control," and variants thereof, is being developed for use in controlling flexible structures and other dynamic systems for which mathematical models of the dynamics are poorly known. Unlike classical control techniques, anticipatory neurofuzzy control can even be applied to systems for which the mathematical models are unknown. In comparison with classical controllers and older fuzzy-logic controllers, an anticipatory neurofuzzy controller is more robust in the sense that it has superior ability to act during operation to compensate for, and adapt to, errors in the mathematical model of the dynamics, changes in the dynamics, and noise.

Anticipatory neurofuzzy control is a hybrid of two older fuzzy-logic control techniques: (1) standard (nonpredictive) fuzzy control, in which rules are used to

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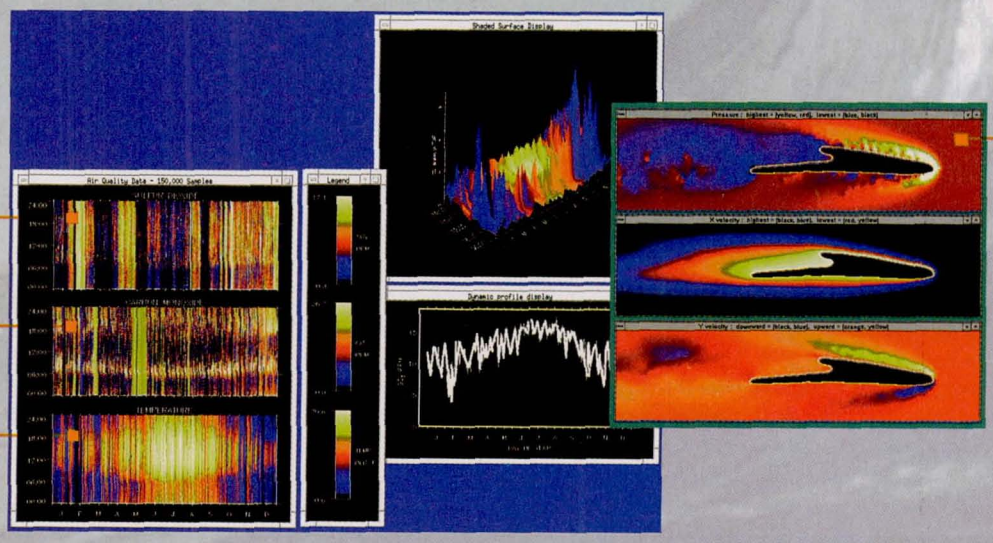
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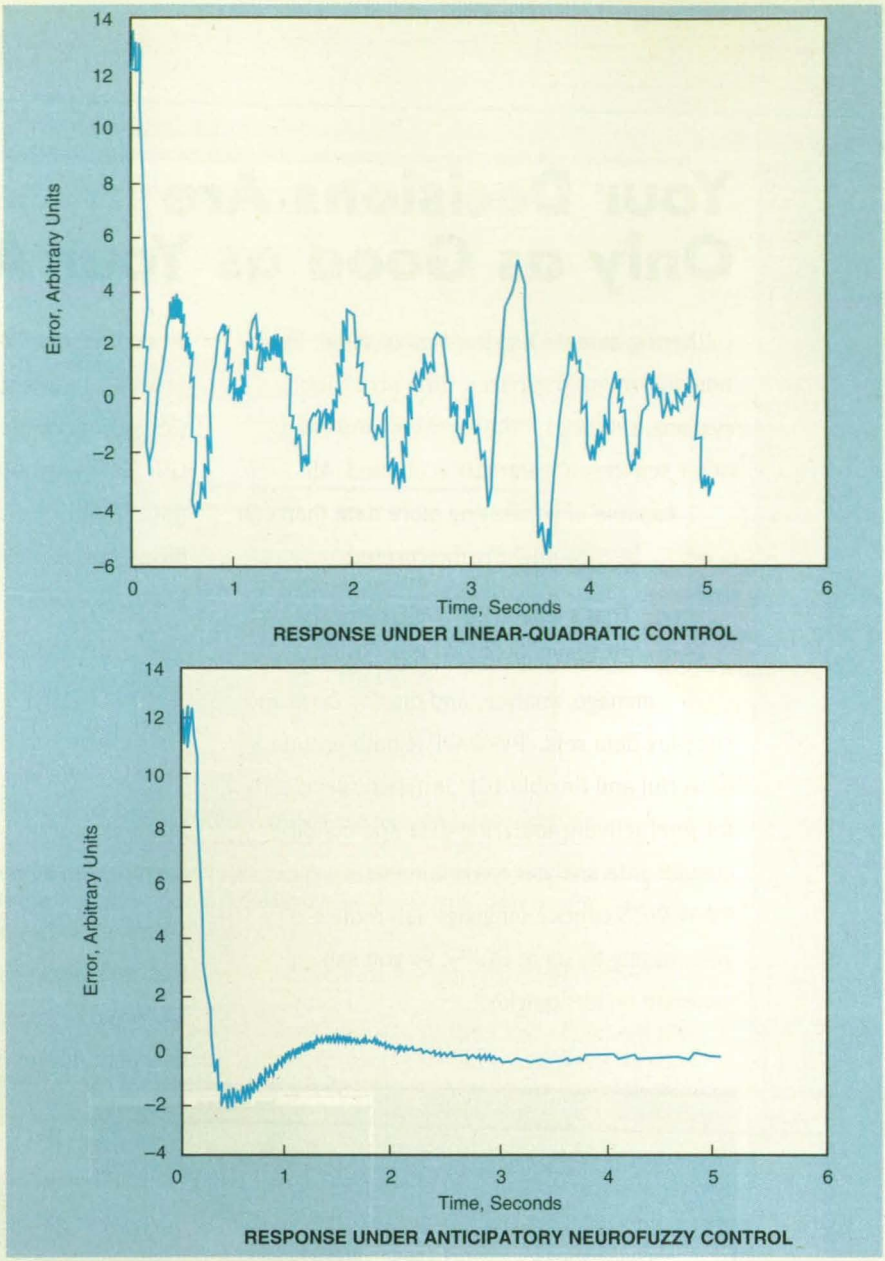
For More Information Write In No. 670

generate control signals based on the past performance of the system, and (2) predictive fuzzy control, in which signals are based on the effects, predicted by the applicable mathematical model, of those signals on the system. Before an anticipatory neurofuzzy controller is designed, a neural network is trained, by use of measured input and output data, to effect the desired control actions. The neural network is then used (instead of an explicit mathematical model of the dynamics) to perform the predictive control computations.

In the anticipatory neurofuzzy controller, fuzzy rules are first used to generate control signals in the standard manner; that is, based on past states of the system. However, unlike in a standard fuzzy controller, these signals are not sent directly to the control actuators of the system: instead, they are sent to the neural network, which predicts the effects of these signals on the system. If the predicted effects are undesirable in some way (for example, if they include or would lead to unstable behavior), then the control signals are not passed on to the control actuators; instead, a new set of fuzzy rules is invoked. Thus, undesirable behavior of the system is prevented, and fuzzy rules are nested.

In addition to increased robustness, anticipatory neurofuzzy control offers the advantage of reduced computing time: The nesting of rules reduces the incidence of calls to predictive routines, with consequent decrease of time spent in control computations. The use of the neural network to make predictions reduces computation time further in that neural networks are inherently amenable to implementation in high-speed circuitry.

The performances of an anticipatory neurofuzzy controller and other controllers were measured in experiments on a flexible beam mounted at one end with springs and a rotary actuator. In each case, the free end of the beam was initially set at a specified error (distance) from the zero-error position, and the control objective was to use the rotary actuator to return the free end to the zero-error position. The figure presents typical responses that illustrate the superiority of the anticipatory neurofuzzy controller over the linear-quadratic controller. Other experimental data (not shown in the figure) also indicate that the anticipatory neurofuzzy controller perform better than other fuzzy-logic controllers do.



The **Dynamic Response** under anticipatory neurofuzzy control was less affected by noise than was the response under linear-quadratic control.

This work was done by Claire L. McCullough of the University of Alabama in Huntsville for **Marshall Space Flight Center**. *For further information,* ***write in 4*** *on the TSP Request Card.*
MFS-26227

Portable Presentation and Instruction Unit

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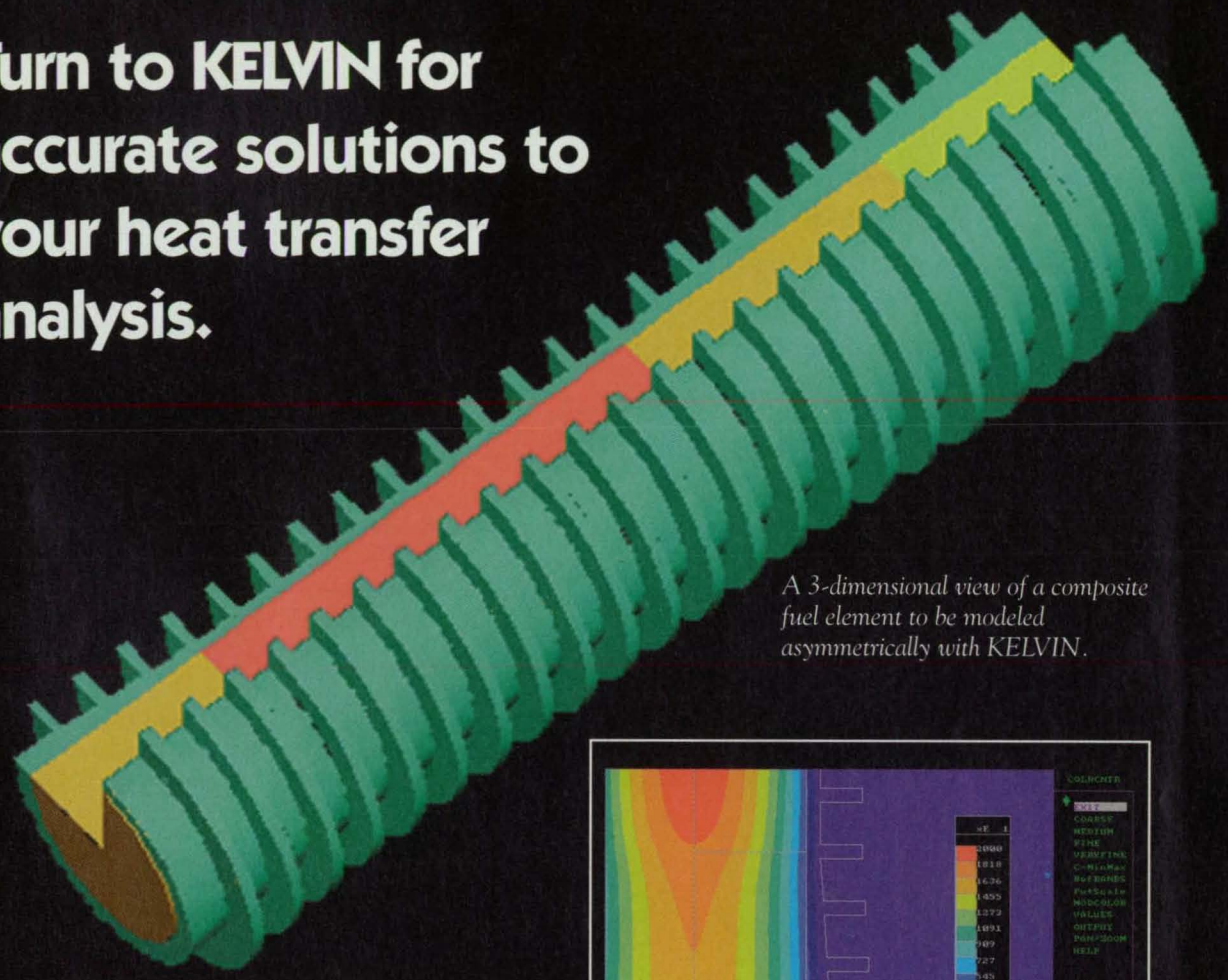
Lyndon B. Johnson Space Center, Houston, Texas

A proposed electronic display unit reminiscent of a kiosk would serve as a portable, interactive, multimedia information terminal. The unit could be used as a traveling science exhibit, an aid for teaching science in schools, or a training and skill-refresher device for space flight crews, for example.

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and audio displays, including three-dimensional-appearing video simulations. In the original intended application, it would provide access to a large collection of data on research and development projects in the life sciences. A touch screen, voice-recognition device, track ball, and keyboard would be provided to enable the viewer to select display options. Programs could be transferred via disk, modem, or network and would be updated periodically.

The unit would speed learning and improve retention by applying principles of scientific visualization. It would also help previously trained but recently unpracticed personnel relearn their special skills and procedures quickly.

This work was done by L. Christman and N. Hoang of G. E. Government Services for **Johnson Space Center**. *For further information,* ***write in 24*** *on the TSP Request Card.*
MSC-22063

Reducing Spurious Output of NCO's

A random noise signal is added to either amplitude or phase prior to truncation.

NASA's Jet Propulsion Laboratory, Pasadena, California

The spurious frequency components in the output of a numerically controlled oscillator (NCO) can be reduced by dithering the appropriate digital signals with a small random noise signal prior to truncation. In the absence of noise, the spurious components are caused by the periodic errors inherent in the repeating finite-word-length digital representations of the sinusoid (see Figure 1). The errors and the spurious components become more pronounced when the digital representation is truncated to fewer bits. The levels of the spurious components are about 6 dB per bit of representation below the desired sinusoidal signal.

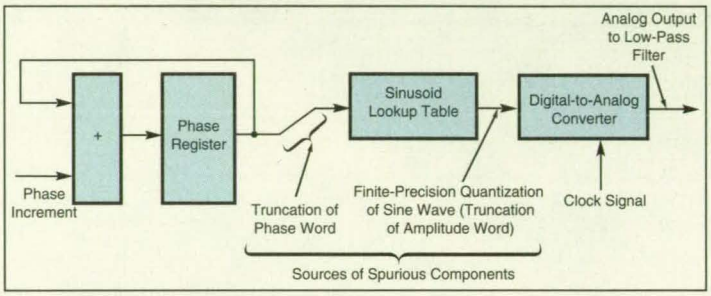
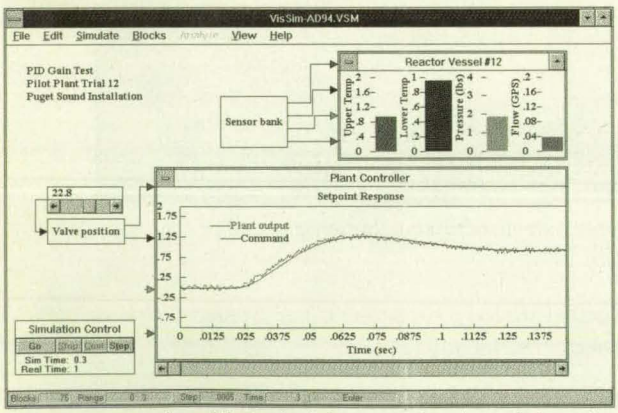


Figure 1. **Truncation of the Phase or Amplitude** gives rise to spurious components in the output of a numerically controlled oscillator.

The dithering process can be viewed as enabling reduction of the word length without increasing spurious signal power. The first step in the dithering process is the addition of a random noise signal to either the phase or amplitude value, which is originally expressed with a long word-length. Then the resulting sum, which is

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the dithered phase or amplitude value, is truncated or rounded to the desired shorter word length. Typically, the maximum magnitude of the random noise signal is commensurate with the least-significant bit of the new, reduced word length. An NCO that performs the dithering process for the amplitude samples is shown in Figure 2. An equivalent process can be performed on the phase samples. In that case, the reduced-word-length dithered phase values are sent as input to a look-up table that contains the corresponding amplitude values.

The advantage gained by dithering the amplitude is that the spurious components in the output at the shorter word length are reduced to the level of the spurious components at the original greater word length. The disadvantage is that the reduced components are accompanied by noise. However, this disadvantage is mitigated by the fact that the noise is either spread over the entire sampling frequency range or else concentrated within a passband acceptable for subsequent filtering.

The reduced word length enables the use of less-complicated multipliers in purely digital applications. In a typical analog application, this dithering method enables the generation of signals with high nonharmonic spectral purity by use of a fast video digital-to-analog converter, the word length of which is typically limited to no more than 8 to 12 bits.

The advantage gained by dithering the phase is either to improve the spurious performance to that of the original longer phase word length or else to steepen the typical 6-dB-per-bit falloff of the spurious components to 12 dB per bit. Because the size of a sinusoid lookup table is exponentially related to the number of phase bits, this dithering technique can dramatically reduce the complexity of an NCO. The noise required for the dithering process can be generated efficiently in approximate form as a pseudonoise sequence by use of a linear feedback shift register.

This work was done by George A. Zimmerman and Michael J. Flanagan of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 71*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office–JPL [see page 20].
Refer to NPO-18789.

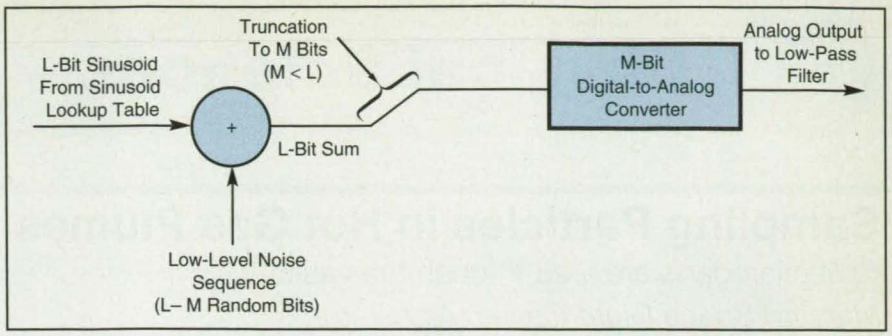
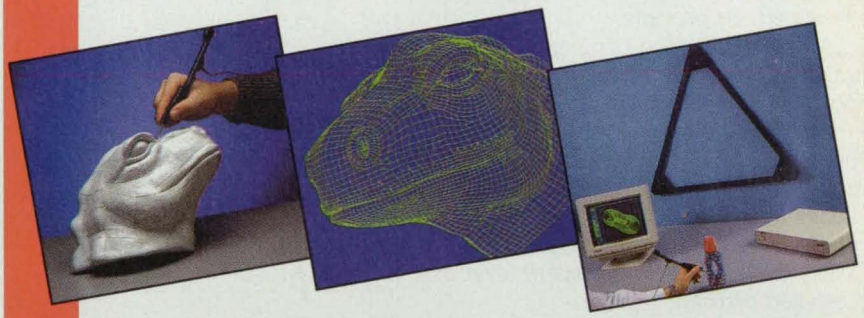


Figure 2. **Low-Level Noise** is added to the digital representation of the sinusoid, and the sum is truncated. The effect is to add white noise and reduce spurious periodic components.

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For More Information Write In No. 407

Sampling Particles in Hot Gas Plumes

Collection darts are fired through the gases.

Marshall Space Flight Center, Alabama

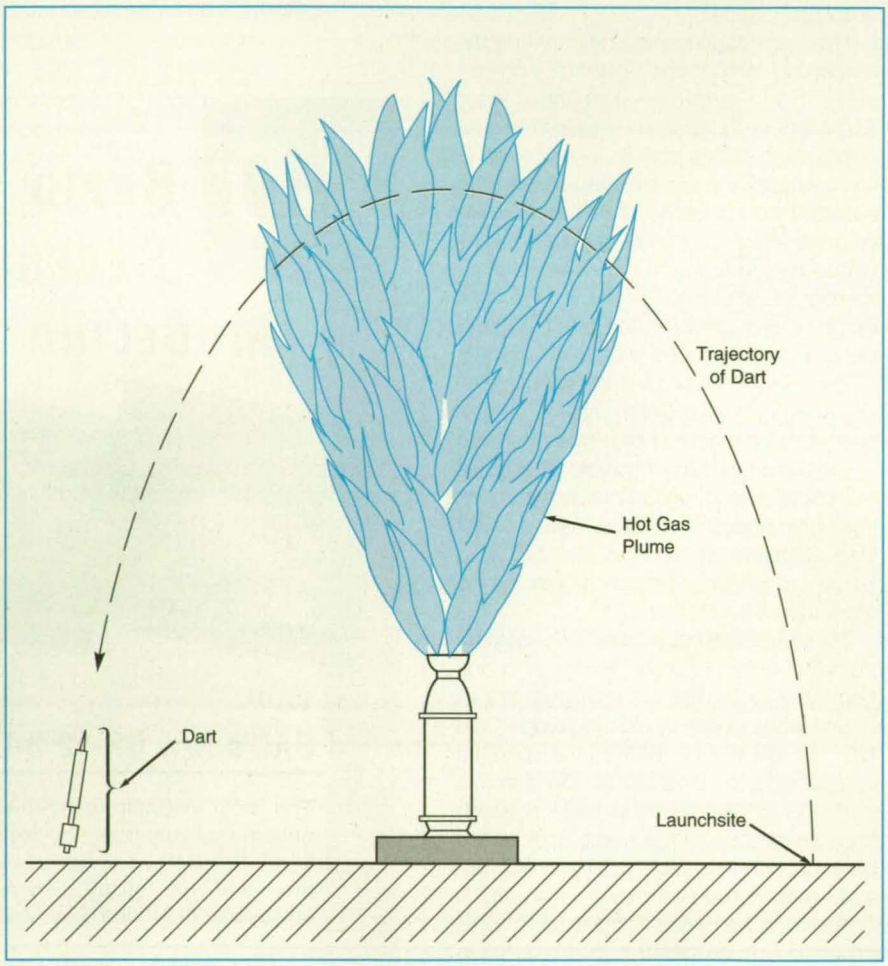
Sampling darts and a launching apparatus have been built to collect particles in a vertical plume of hot gas. In the original application, the hot gas plume is a rocket-engine exhaust during a test firing. The darts and launcher may be adaptable to a variety of terrestrial uses like research on particulate emissions of volcanoes or determining the origin of a building fire while it is still burning.

The basic idea is to send darts periodically through the hot gas plume. Double-sticky-sided foil carried by the dart gathers particles en route.

A dart is first placed on a launch tube, which in turn is mounted on the outlet port of a solenoid-controlled dump valve. The valve is opened, releasing a blast of high-pressure nitrogen into the tube and sending the dart on an approximately parabolic trajectory through the plume (see figure). The dart is recovered, and the sticky foil is removed for examination of collected particles.

The pressure of the nitrogen can be varied to adjust the trajectory. For example, with a pressure sufficient to produce a launch speed of 125 ft/s (38 m/s) and with the dart aimed at 80° up from horizontal, the dart attains a height of about 235 ft (72 m) and a range of 166 ft (50.6 m) along a purely ballistic trajectory. In practice, the plume can give the dart some aerodynamic lift, extending the height and range beyond the purely ballistic values.

The dart is made of stainless-steel tubing 1½ in. (38.1 mm) in diameter and 0.095 in. (2.4 mm) thick. It weighs about 14 lb (about 6.4 kg).



The **Dart Travels** through a plume of hot gas, gathering particles from the plume. Passes can be made at various heights, depending on the launch angle and launch-gas pressure.

This work was done by James F. Taylor and Jay Sambamurthi of **Marshall Space Flight Center**. *For further information,* ***write in 102*** *on the TSP Request Card.*
MFS-28729

Techniques for Focusing in Zone Electrophoresis

Velocity- and field-gradient focusing could be used in rectangular and step-shaped chambers, respectively.

Marshall Space Flight Center, Alabama

In two techniques for focusing in zone electrophoresis, the force of the applied electrical field in each charged particle is balanced by the restoring force of electro-osmosis. The two techniques are velocity-gradient focusing (VGF), which is suitable for rectangular electrophoresis chambers; and field-gradient focusing (FGF), which is suitable for step-shaped electrophoresis chambers. In VGF, the electrical-field strength, E, is held constant along the direction of electrophoresis ($dE/dx = 0$,

where x, is the position along the direction of electrophoresis), whereas the opposing electro-osmotic velocity, V_{eo}, increases along x, as shown in Figure 1. In FGF, V_{eo} is held constant with x, whereas E decreases along x, as shown in Figure 2.

The theoretical basis for both VGF and FGF is the Smoluchowski equation, which expresses the relationship among V_{eo}, E, and the ζ potential of the wall:

$$V_{eo} = \zeta DE/4\pi\eta$$

where D and η are the dielectric constant and the viscosity, respectively, of the buffer medium. This equation predicts that for a given buffer (constant D and η), V_{eo} can be controlled by varying the ζ potential of the wall.

Figure 1 schematically illustrates VGF in an open chamber of rectangular cross section. The V_{eo} profile is plug shaped, with the velocity counter to the direction of electrophoresis. Furthermore, the rectangular cross section ensures that E is independent of x. Thus, a series of step changes in ζ along x should lead to a series of step changes in V_{eo}, making it possible to focus particles of different mobilities in zones of different ζ.

Figure 2 schematically illustrates FGF in an open step-shaped chamber. Again, the V_{eo} profile is plug shaped, but unlike in the rectangular chamber, the field strength and therefore V_{eo} vary with the thickness of the chamber. However, by making the ζ potential inversely proportional to E at each step, it should be possible to make V_{eo} independent of x, leaving only a gradient in E.

A crucial feature of the VGF and FGF modifications is the adjustment of V_{eo}. This can be done by coating the walls with a protein (or other suitable substance) that has the desired ζ potential under the operating conditions. However, a better technique would be to adjust the potential of the wall directly, as shown in Figure 1.

This work was done by Rizwan Sharnez, Garland E. Twitty, and David W. Sammons of the University of Arizona for **Marshall Space Flight Center**. *For further information,* ***write in 65*** *on the TSP Request Card.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

The University of Arizona
Att: Richard A. Haney,
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Refer to MFS-26179 volume and number of this NASA Tech Briefs *issue, and the page number.*

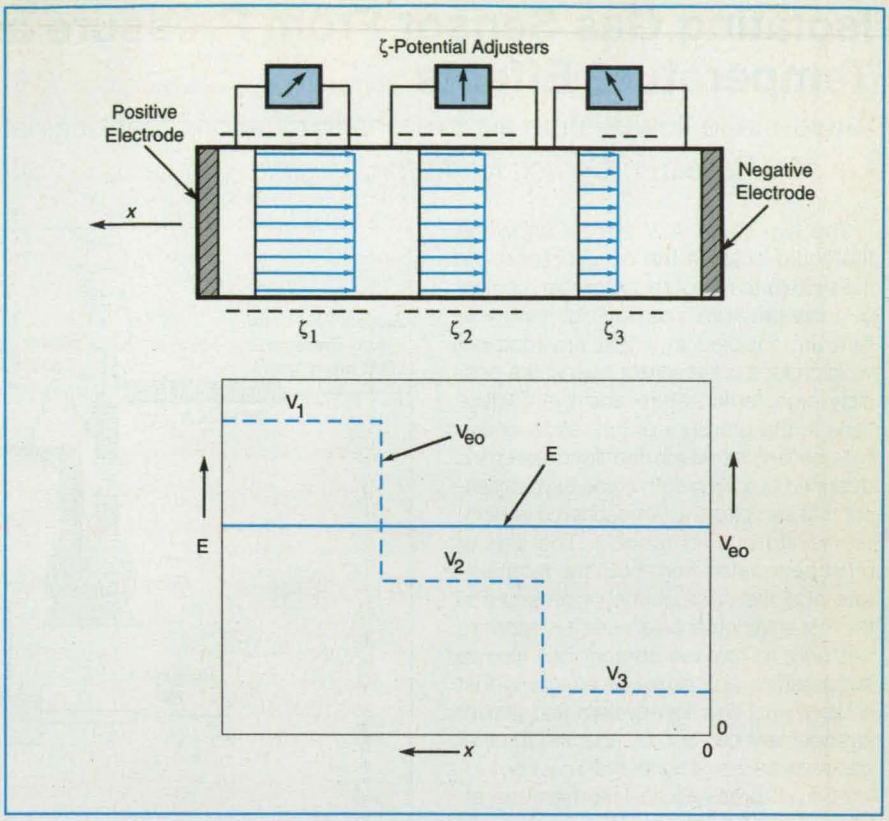


Figure 1. In **Velocity-Gradient Focusing (VGF)**, the ζ potential is adjusted in steps to obtain the desired steps in V_{eo}.

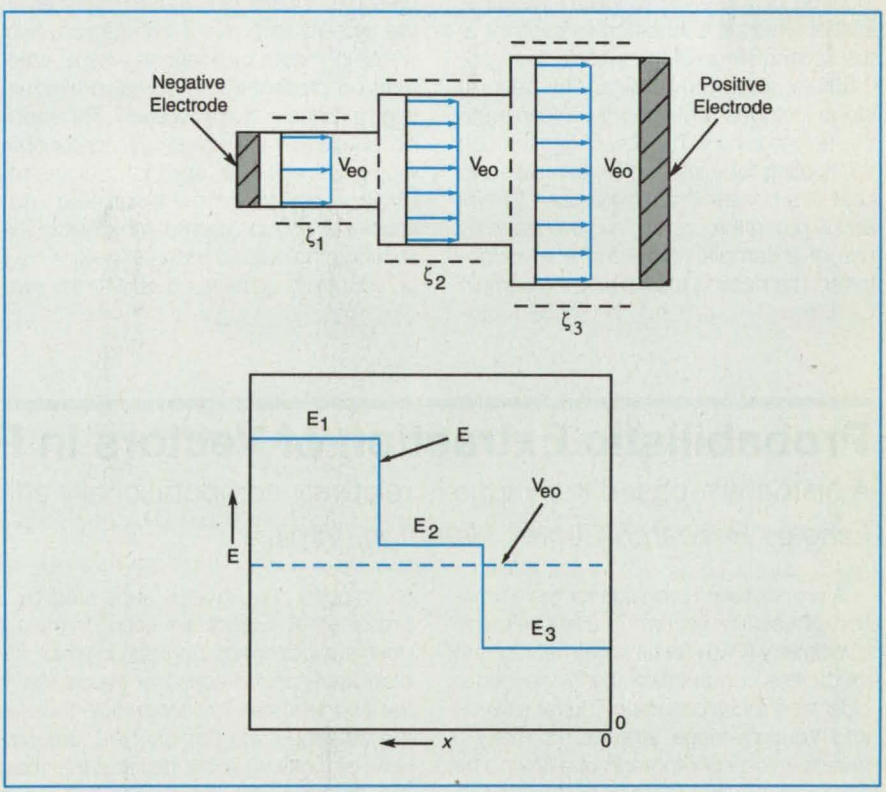


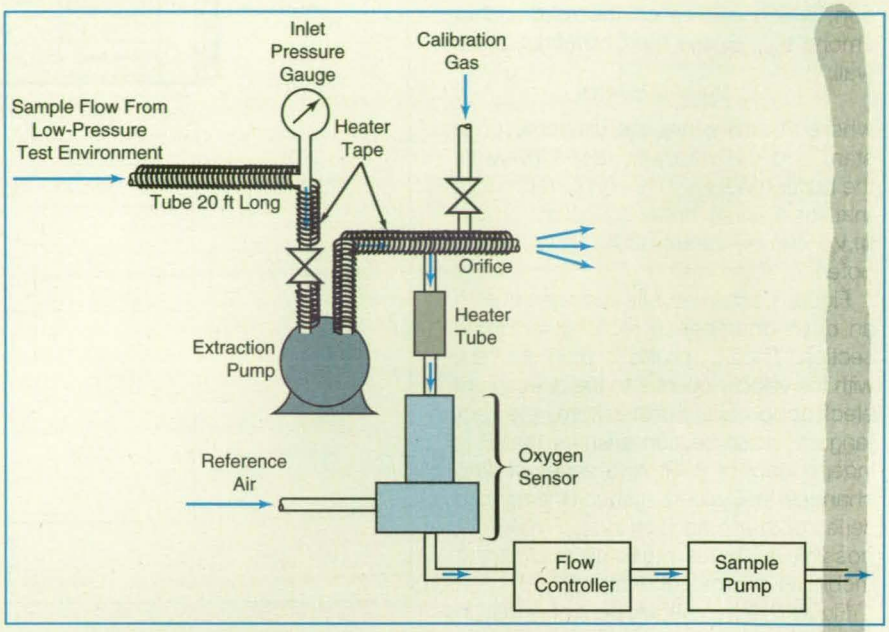
Figure 2. In **Field-Gradient Focusing (FGF)**, V_{eo} is maintained constant along x, while E changes in steps.

Isolating Gas Sensor From Pressure and Temperature Effects

A two-stage flow system suppresses fluctuations that originate in the sampled atmosphere.

Langley Research Center, Hampton, Virginia

The two-stage flow system shown in the figure enables the oxygen sensor in the system to measure the oxygen content of a low-pressure, possibly-high-temperature atmosphere in a test environment while protecting the sensor against the possibly high temperature and the fluctuations in the pressure of that atmosphere. (The sensor for which the flow system is designed is a zirconium oxide oxygen sensor that samples the atmospheres in high-temperature wind tunnels. The sensor must be isolated from both the temperature and the fluctuations of pressure in the test environment because it is sensitive not only to oxygen content but also to temperature and pressure effects in that environment.) This flow-system-and-sensor arrangement can also be adapted to other gas-analysis instruments that must be isolated from pressure and temperature effects of test environments.



This **Two-Stage Flow System** isolates an oxygen sensor from pressure and temperature effects in the atmosphere of the test environment.

A sample stream of gas is withdrawn from a low-pressure [typically, 2-psi (14-kPa)] test environment by a metal bellows extraction pump and directed to a T-fitting, one end of which is open to the atmosphere [14 psi (about 97 kPa) at the location of the wind tunnels], the other end of which is connected to the inlet of the second stage of the system through a 0.035-in. (0.89-mm) orifice. The second stage includes a heating tube leading to the oxygen sensor. The flow of gas through the heating tube into the oxygen sensor is kept at a constant rate (typically 4 L/min) and is pulled through the second stage by use of a sample pump and a flow controller. The heating tube heats the sample flow to a constant temperature, and the open-ended T ensures a constant sample pressure. Heater tape is used elsewhere in the system to prevent condensation of water in those applications where water may be present in the sampled medium (e.g., products of combustion). Reference air, required by the oxygen sensor for optimum operation, is sent to the sensor through another flow controller (not shown). A port located near the inlet of the second stage allows gases of various oxygen concentrations to be sent to the sensor for calibration.

This work was done by of Danny R. Sprinkle of **Langley Research Center** *and Tony T. D. Chen and Sushi K. Chaturvedi of Old Dominion University. No further documentation is available.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 20].
Refer to LAR-14791.

Probabilistic Extraction of Vectors in PIV

A histogram-based technique is relatively computationally efficient.

Langley Research Center, Hampton, Virginia

A probabilistic technique for the extraction of velocity vectors in particle-image velocimetry (PIV) can be implemented with much less computation than is needed in older techniques based on Fourier analysis and Young's-fringe analysis. To make a particle-image photograph of a flow to be analyzed by this technique, the flow is seeded with particles and illuminated by a sheet of pulsed laser light as in other PIV techniques. Two pulses separated by a preset small interval are used, forming a double-exposure photograph in which the magnitude and direction of separation of the two images of each particle indicate the velocity of the particle (and, presumably, of the flow) in the plane of the sheet of light at the time of exposure (see Figure 1). The photograph is divided into discrete interrogation regions; histograms of the magnitudes and directions of all possible vectors that can be drawn between pairs of particle images in the interrogation regions are constructed. From the ensemble of all possible vectors in each interrogation region, those that appear to be most probable on the basis of the histograms are selected as the velocity vectors in that region (see Figure 2).

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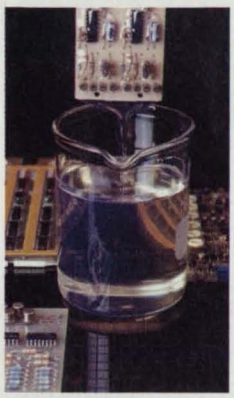


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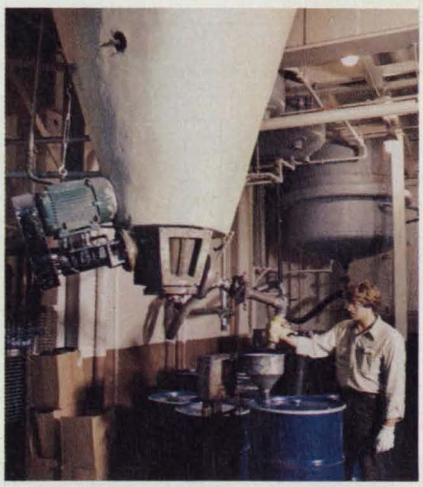
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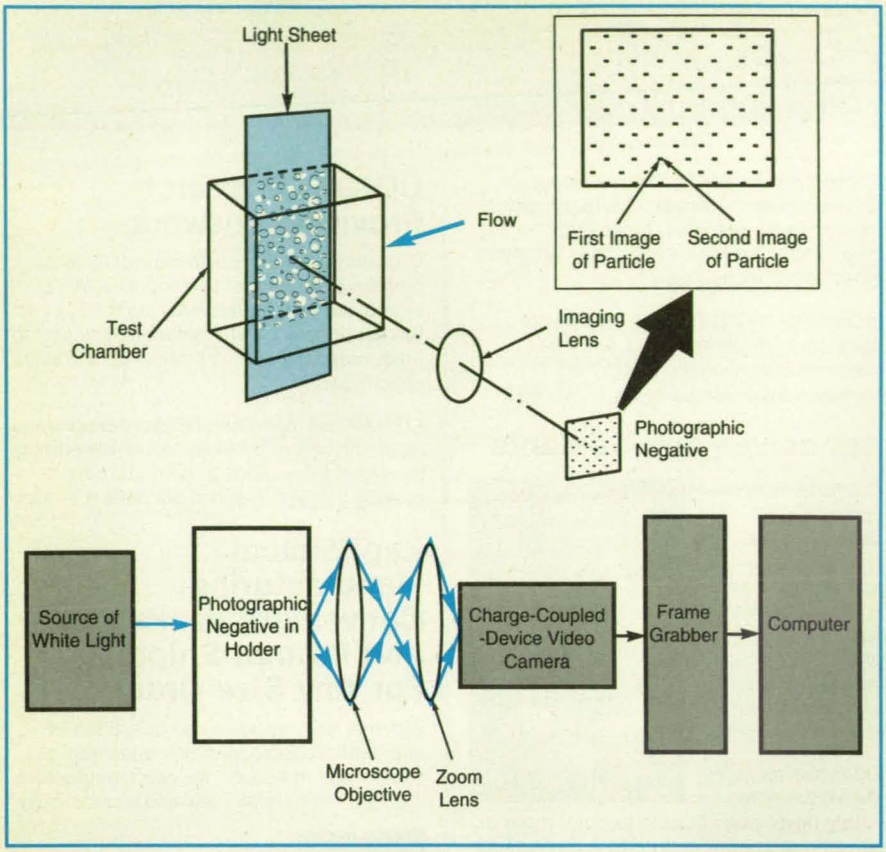


Figure 1. A **Double-Exposure Photograph** of particles in a flow illuminated by a sheet of light provides data on the velocity field of the flow. The photograph is converted into a video image, which is then digitized and processed by a computer into the velocity-field data.

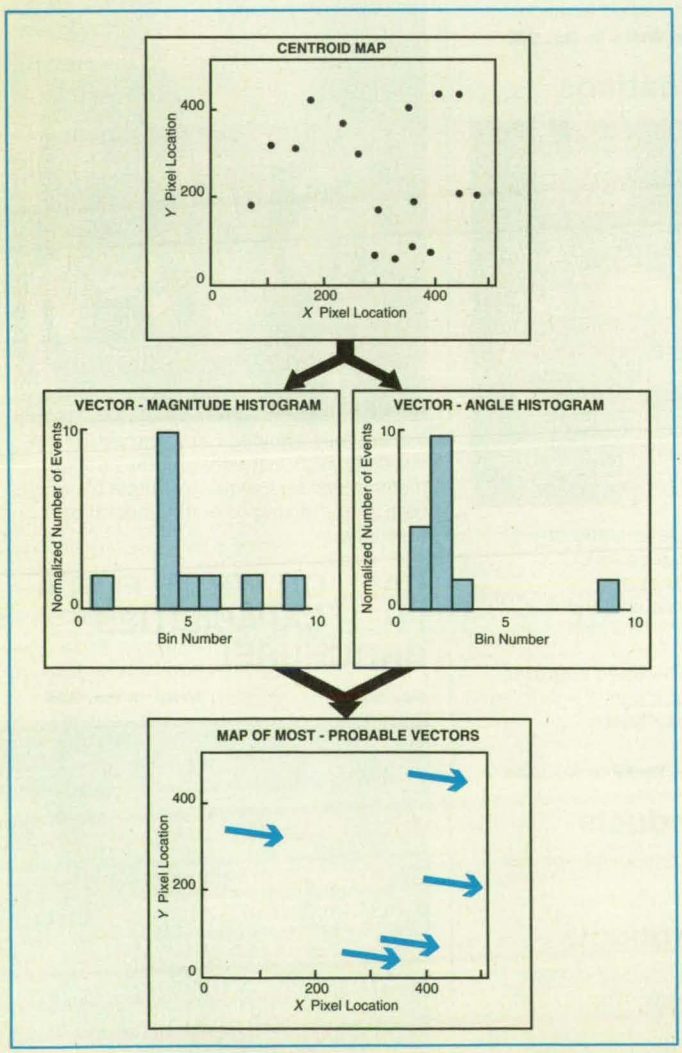


Figure 2. **Velocity Vectors in an Interrogation Region** are chosen from magnitude and angle histograms constructed from the centroid map of the region.

graph by this technique, magnified video images of the interrogation regions are first generated by use of a charge-coupled-device video camera equipped with a zoom lens and a microscope objective. The output of the video camera is sent to a frame grabber, then to a computer for processing. During the acquisition of the magnified video images, the photograph is illuminated by white light and mounted on a translation stage, which is used to scan incrementally over the flow field (see Figure 2).

The image of each interrogation region is thresholded to reduce noise, then processed into a centroid map, which is essentially a simplified version of the image in which a single-pixel dot indicates the centroid of the image of each particle. The vector and histogram computations are then performed, using the centroids as the locations of the particles.

To quantify the probability of detection of valid vectors in this technique, a limited simulation study has been performed. The results of this study indicate that there are strong correlations among the density of particle images, the separations between the double-exposure images of the particles, and the vector-detection rate. The results suggest that to obtain a valid-vector-detection rate of 90 percent or more, the number of image pairs per interrogation region must be maintained between 3 and 7, with a separation of no more than 20 percent of the size of the interrogation region. Thus, the accuracy of the technique depends heavily on how well the densities and separations of image pairs are controlled during the analysis.

In a demonstration of the technique, PIV photographs taken in air of the flow around an airfoil were analyzed. By maintaining the density of image pairs in the interrogation regions close to 5, a false-vector-detection rate of approximately 5 percent was obtained. This is consistent with the results of the simulation study.

This work was done by William M. Humphreys, Jr., of **Langley Research Center**. *For further information,* ***write in 31*** *on the TSP Request Card.*
LAR-14798

Apparatus Removes Organic Contaminants From Water

A catalytic oxidizer operates at moderate temperature and pressure.

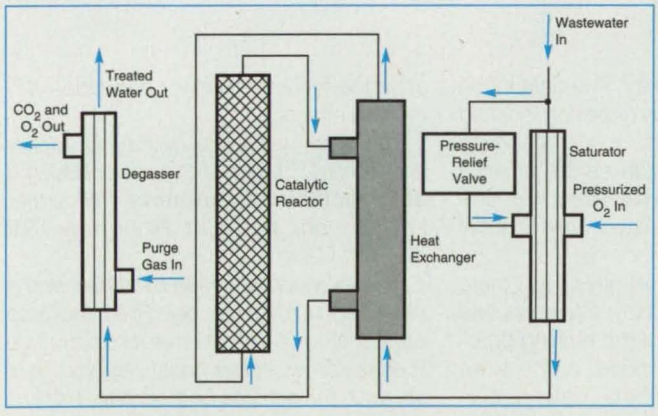
Marshall Space Flight Center, Alabama

A catalytic-oxidation apparatus removes low-molecular-weight, polar, nonionizable organic contaminants from wastewater. Older water-reclamation apparatuses based on sorption and ion exchange are ineffective in eliminating such materials, which include alcohols, aldehydes, ketones, amides, glycols, and thiocarbamides. This catalytic-oxidation apparatus reduces the total amount of organic carbon in the effluent to less than 350 parts per billion (ppb) — below the maximum allowable level of 500 ppb established by NASA for potable water in its life-support systems.

The apparatus (see figure) includes an oxygen saturator, in which oxygen passes through hollow, permeable fibers, into the influent stream, where it is dissolved (see figure). A regenerative heat exchanger preheats the oxygen-saturated influent. (The heat exchanger draws heat from the effluent, which is heated during the catalytic oxidation step.)

The influent enters the catalytic reactor, where its organic contaminants are oxidized by physical and chemical processes at the surface of the catalyst. For example, a primary alcohol like ethanol is adsorbed along with oxygen on the catalyst, and is then oxidized to the corresponding organic acid. This reaction is followed by a slower oxidation of the organic acid to form carbon dioxide and water. Larger contaminant molecules pass through intermediate stages; for example, isopropanol is partially oxidized to form acetone, which in turn is oxidized to carbon dioxide. Of the catalysts tested in a prototype reactor, the most effective have consisted of platinum and ruthenium on carbon supports.

The effluent from the catalytic reactor passes through the heat exchanger, where its heat is transferred to the influent. The concentrations of carbon dioxide and unused oxygen in the effluent from the catalytic reactor and heat exchanger depend on the initial concentrations of contaminants and dissolved oxygen. After the effluent has passed through the heat exchanger and transferred much of the heat acquired in the reactor to the influent, oxygen and carbon



The **Wastewater Stream**, previously treated by a multifiltration process, is pumped through this apparatus for removal of trace organic contaminants. After injection of oxygen, the flow is preheated and enters the catalytic reactor, where organic contaminants are broken down into carbon dioxide and water. The carbon dioxide and unused oxygen are removed in the degasser.

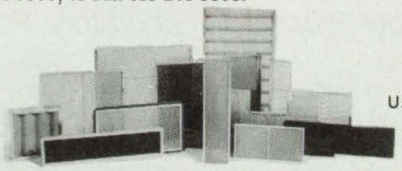
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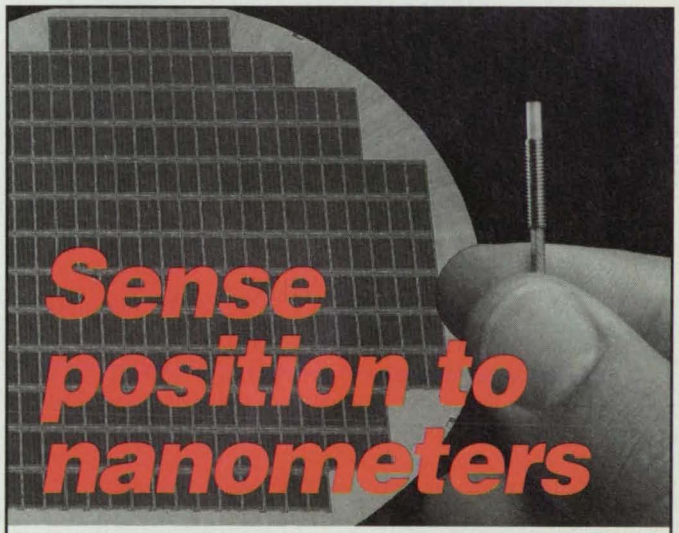
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dioxide are removed from the effluent in the degasser, which contains gas-permeable membranes.

In comparison with other catalytic reactors, the one in this apparatus operates at relatively low temperature (125 to 160 °C) and relatively low pressure [at least 33.7 psi (0.232 MPa) at 125 °C]. The power needed for operation is therefore relatively low. Furthermore, no adjustment of acidity or alkalinity (pH preconditioning) is needed: this apparatus can oxidize organic contaminants in both basic and acidic solutions. The semipermeable membranes used to exchange gases enable precise control of the amount of oxygen available for reactions and the concentration of the gases that remain in the effluent.

This work was done by James R. Akse and John Thompson of Umpqua Research Co. for **Marshall Space Flight Center**. *For further information,* ***write in 25*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 20].
Refer to MFS-26224.

Phase Holograms in PMMA

Complex, computer-generated phase holograms can be more efficient than their binary counterparts have been.

NASA's Jet Propulsion Laboratory, Pasadena, California

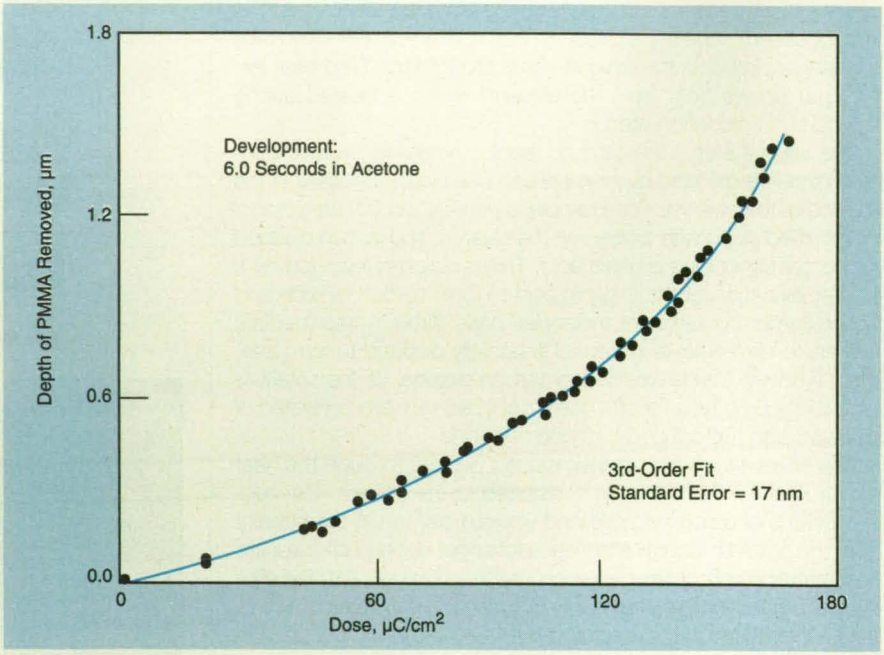
Complex, computer-generated phase holograms can be written in thin films of poly(methyl methacrylate) (PMMA) by a process of electron-beam exposure followed by chemical development. The spatial variations of phase delay in these holograms are quasi-continuous, as distinguished from stepwise as in binary phase holograms made by integrated- circuit fabrication. These holograms are more precise than are binary holograms. The greater continuity and precision of these holograms should result in decreased scattering loss and increased imaging efficiency.

In preparation for fabrication of a hologram, a layer of PMMA of thickness corresponding to somewhat more than one wavelength of optical retardation relative to air is spun on an optical flat. The film then is exposed to a scanning electron beam that is spatially modulated under computer control to generate the holographic pattern, in which a specified phase delay is encoded in each picture element. Next, the pattern is partially chemically developed (analogously to development of a photograph) to render the holographic pattern in relief. Rapid development in a strong developer (e.g., etching for 6 s in acetone) approximately linearizes the dose-response characteristic of the film and thereby enhances the ability to obtain the desired phase delay.

The figure shows a typical dose-response curve and indicates that the depth of etch can be controlled to within ±20 nm, which corresponds to an optical phase shift of ±1/50 of a typical visible wavelength. This curve is characterized by low contrast, which is needed for precise control of depth of etch.

Although the local electron-beam dosage exerts the primary effect on the local depth of etch, there is also a secondary effect (a proximity effect) of dosage at other points in the vicinity. The data in the figure were obtained by exposing isolated 50-μm-square patches, then measuring the depth of etch at the center of each patch, where the proximity effect was uniform and therefore related only to local dosage.

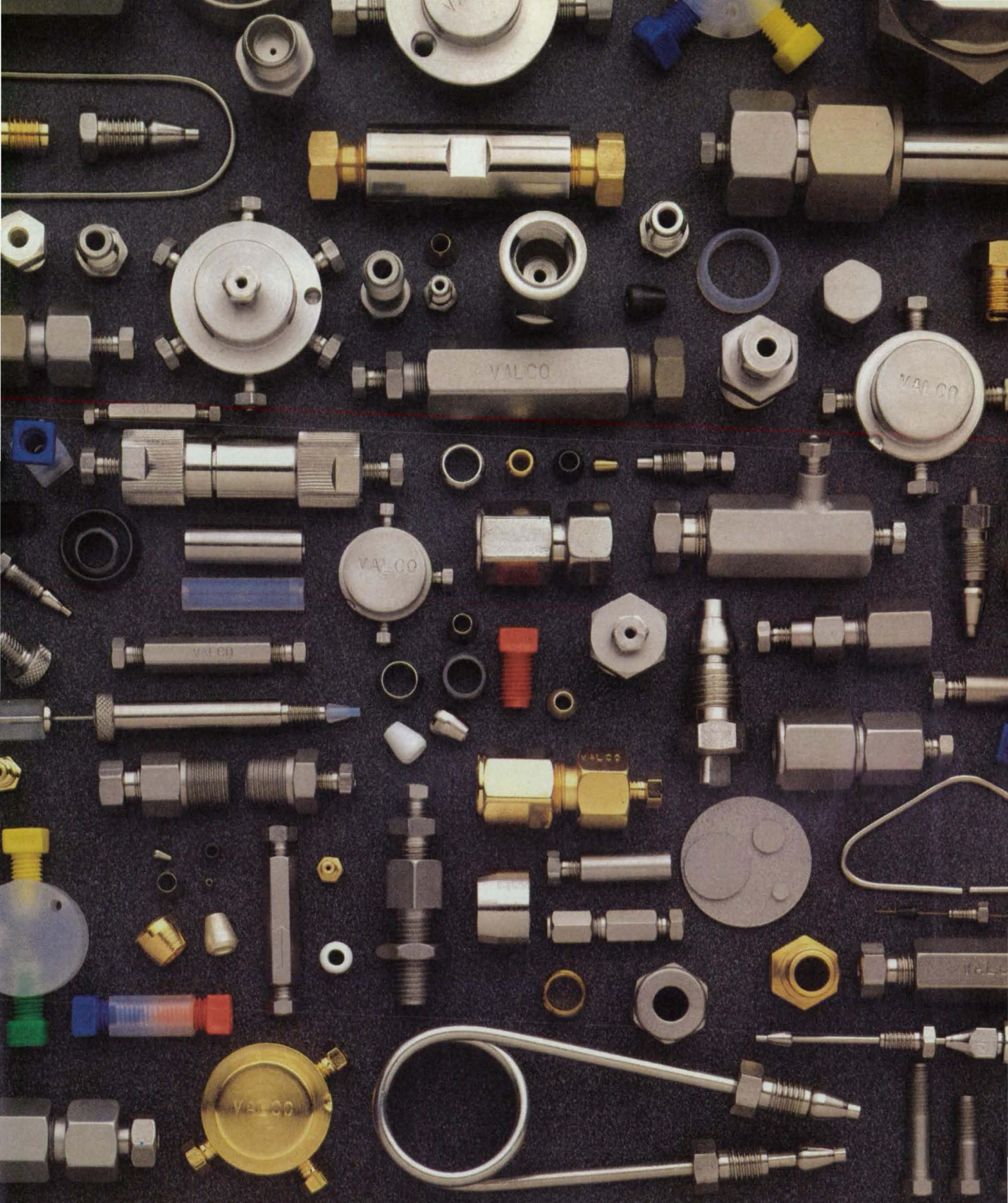
In addition to the proximity effect, there is also a side-wall-etching effect caused partly by the isotropy of the etching process. A mathematical model of the side-wall-etching effect might be used to correct for it via further modification of the local electron-beam dose. In exposing a complicated phase hologram with picture elements that are about as large as (or smaller than) the characteristic radius of the proximity effect, it would be desirable to modify the local dosage to correct in advance for the proximity and side-wall-etching effects.



The **Thickness of PMMA Removed** and thus the phase delay varies continuously with the local electron-beam dose.

This work was done by Paul D. Maker and Richard E. Muller of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 20*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office– JPL [see page 20].
Refer to NPO-18791.



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Polyamideimides Containing Carbonyl and Ether Linkages

Crystallinity is introduced to improve processability.

Langley Research Center, Hampton, Virginia

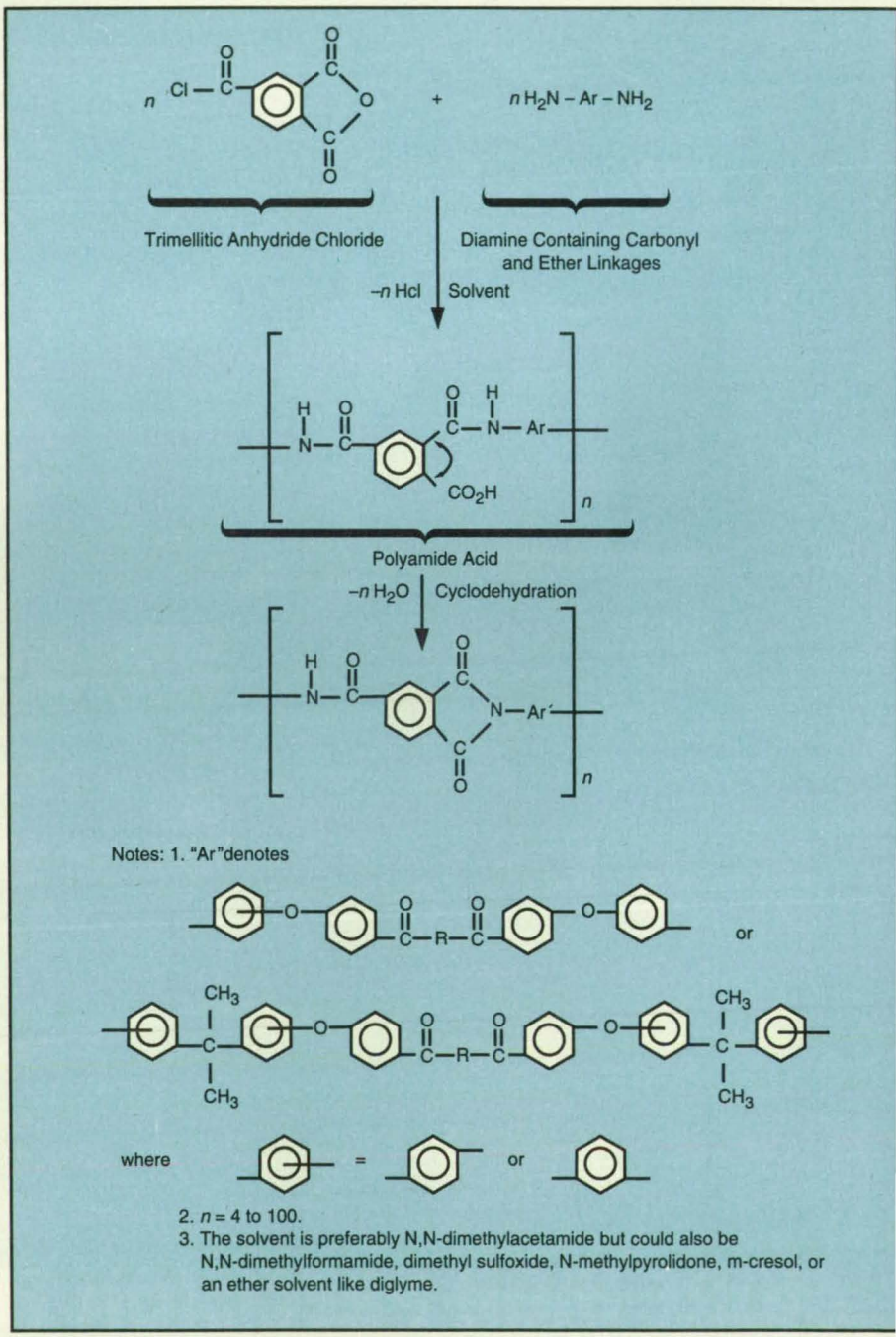
Polyamideimides of a new class contain carbonyl and ether connecting groups. The new polyamideimides are more easily processable, stronger in tension, and more resistant to solvents (including water) than the conventional polyamideimides are. The improvements in mechanical and chemical properties are attributable to the semicrystallinity that is introduced into the otherwise amorphous polymers by the incorporation of the carbonyl and ether linkages.

The carbonyl and ether linkages are incorporated into a polyamideimide of the new type via one of the novel diamines. The diamine is reacted with trimellitic anhydride chloride (see figure), trimellitic trichloride, trimellitic anhydride, monomethyltrimellityl chloride, or trimellitic acid. The resulting intermediate product — a polyamide acid — is then cyclodehydrated to the polyamideimide either chemically or by heating to a temperature above 150°C.

The best overall combination of properties was obtained by the synthesis of copolymers of the polyamideimides. For example, the copolyamideimide from the reaction of trimellitic anhydride chloride with a 60:40 mole percent mixture of 1,3-bis(4-aminophenoxy-4′-benzoyl)benzene and 1,4-bis(4-aminophenoxy-4′-benzoyl)benzene formed a tough, solvent resistant semicrystalline film with a glass-transition temperature of 224°C and a crystalline melt transition at 347°C. Tensile strength, tensil modulus, and elongation at break of this film were determined to be 17,600 psi (121 MPa), 495,000 psi (3.4 GPa), and 9.5 percent at 25°C; 8700 psi (60 MPa), 407,000 psi (2.8 GPa), and 2.7 percent at 177°C; and, 7000 psi (48 MPa), 315,000 psi (2.2 GPa), and 39.4 percent at 200°C, respectively.

This work was done by Paul M. Hergenrother of **Langley Research Center** *and Stephen J. Havens of Planning Research Corp. For further information,* ***write in 26*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Langley Research Center [see page 20]. Refer to LAR-14186.



Carbonyl and Ether Linkages are incorporated into the final polyamideimide product via the diamine reactant.

Easily Processable High-Temperature Polyimide

Polymerization without volatile gases leads to high-quality resins.

Lewis Research Center, Cleveland, Ohio

Polymers are making their way into a variety of uses in aircraft. The primary impetus for the use of polymer matrix materials is a net saving of weight for air and space vehicles. The design of advanced aircraft requires the saving of weight to increase thrust-to-weight ratios for superior performance. Both performance and cost of advanced materials will provide the impetus for the use of polymeric matrix materials in future aircraft and spacecraft designs. Yet the performance of polymeric materials in advanced aircraft engines suffers in environments where temperatures rise above 300°C (575°F).

Two resins that have been developed at Lewis Research Center to replace metals in aircraft engines are PMR-15 and PMR-II-50. Where temperatures can reach 300°C, PMR-15 is the resin of choice. PMR-II-50, a higher-temperature thermoset polyimide, is being considered for use in aircraft-engine components that operate at temperatures up to 371°C (700°F). The end-cap compound used in PMR-15 and PMR-II-50 is nadic acid-ester. Nadic acid-ester contains many aliphatic carbon atoms, which limit upper use temperature in both PMR-15 and PMR-II-50. Also, during polymerization, this end cap emits a gas (see Figure 1) that must be entrained completely during the polymerization process, or voids occur in the cured resin.

N-CYCAP (amiNe substituted CYClophane Addition Polyimide) is a thermoset polyimide developed at Lewis Research Center. N-CYCAP contains 4-amino[2.2]paracyclophane as its end cap (see Figure 2). Each of the pairs of aromatic rings of the cyclophane end cap is held together by two two-carbon bridges: this imparts a large strain energy to the end cap. To relieve the strain, the bond between one of the two-carbon bridges in each pair of aromatic rings ruptures at 250°C (480°F) and polymerizes to form a highly aromatic, cross-linked polyimide. No volatile gases are evolved during the polymerization process.

Previously, the synthesis of the 4-amino[2.2]paracyclophane end cap was a long, low-yield process. Current improvements in the synthesis of the end cap include increasing the yield to 60 percent overall and decreasing the manufacturing time by simplifying the synthetic procedure. This has enabled large-scale production and increased the viability of cyclophane end caps for polymers for

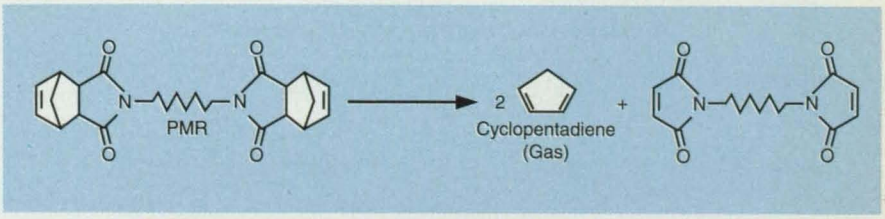
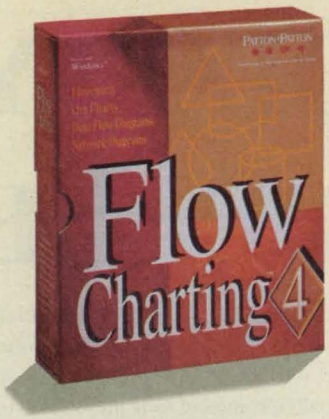


Figure 1. The **Nadic Acid-Ester Emits Cyclopentadiene** during polymerization. Bubbles of cyclopentadiene can give rise to voids in the polymer.

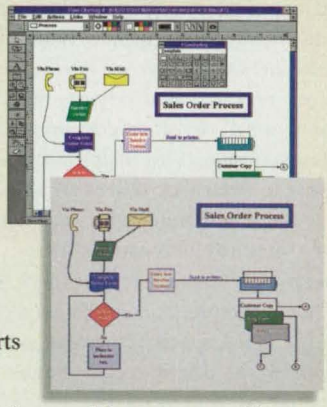


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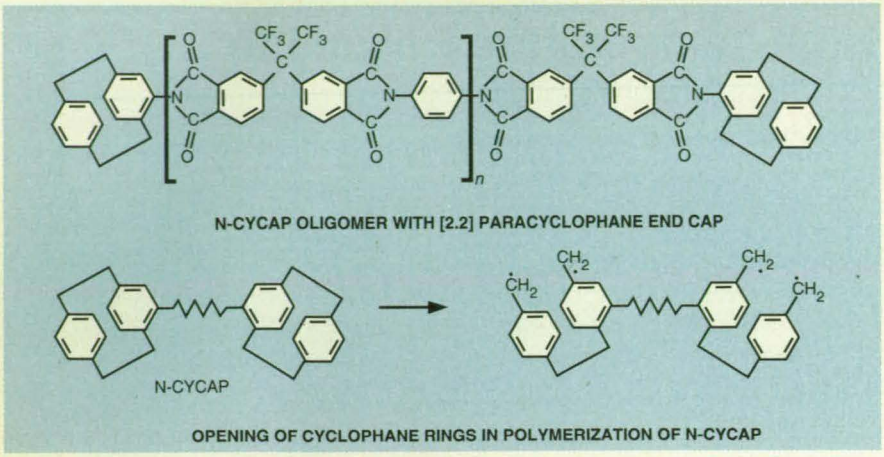


Figure 2. **No Gas Is Emitted** during ring-opening polymerization of N-CYCAP.

high-temperature applications.

Formulation studies with 4-amino[2.2]paracyclophane and a variety of aromatic diamine and dianhydride monomers have been performed to maximize the thermal properties of N-CYCAP. An N-CYCAP formulation that incorporates 4,4'-(hexafluoroisopropylidene)-diphthalic anhydride (HFDA) and a 3:1 mixture of paraphenylene (*p*-PDA) and metaphenylene diamine (*m*-PDA) with a formulated molecular weight of 6,000 atomic mass units (n = 10) has the best combination of properties. The glass-transition temperature of this polymer, determined by thermal mechanical analysis, is between 360 and 390°C (680 and 735°F). In isothermal aging for 1,000 h at 343°C (650°F) in flowing air at 1 atm (0.1 MPa), this polymer retained 86 percent of its weight.

In comparison with neat resin moldings and composite matrix resins made of PMR-II-50, those made of N-CYCAP polymers have been found to be processable with lower void content and higher thermo-oxidative stability. Composites that consist of N-CYCAP reinforced by graphite fibers are processed in a simulated vacuum-bag autoclave cure cycle similar to that used for PMR-II-50. The void contents of these composites are as low as 2 percent. The flexural and shear properties of the N-CYCAP polymers are nearly identical to those of PMR-II-50.

This work was done by James K. Sutter, Mary Ann Meador, and Michael A. Meador of **Lewis Research Center**; *John F. Waters of Case Western Reserve University; and Larry J. Baldwin of Ferro Corp. For further information,* ***write in 103*** *on the TSP Request Card. LEW-15611*

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TECHNOLOGY 2004 UPDATE

The world's largest technology transfer conference and exposition returns to our nation's capital this fall. Technology 2004 (November 8-10, 1994, Washington, DC convention center) will feature over 80,000 square feet of exhibits showcasing licensable technologies, new and next-generation products, and engineering services offered by federal labs and high-tech companies; some 100 symposia presentations on government-sponsored research innovations available for commercial development; and daily workshops designed to help businesses learn how to license or otherwise acquire federally-funded technologies and enter into joint ventures with national labs.

Over 8000 engineers, managers, scientists, and entrepreneurs are expected to attend the NASA-sponsored event, which has tripled in size since it began in Washington, DC four years ago.

New features this year include a showcase of technologies and products spun off from the government's Small Business Innovation Research (SBIR) program; a special workshop on how small businesses can successfully obtain SBIR grants; free demonstrations for beginners on how to use the Internet (the worldwide communications system that has been labeled "the on-ramp to the Information Superhighway"; and a one-day photonics technology transfer meeting and exposition. The latter, called LaserTech '94, will be held concurrently with Technology 2004 on November 9 and will include presentations on commercially-promising advances in lasers, electro-optics, fiber optics, and imaging.

A dozen government agencies and 100 of their laboratories nationwide will exhibit and present papers at Technology 2004, including NASA (with a large pavilion in the center of the exhibits hall), the departments of Agriculture, Commerce, Energy, Interior, and Transportation, the Federal Aviation Administration, the National Security Agency, the U.S. Air Force, and the U.S. Navy. Private sector exhibitors will include Hewlett-Packard, Rockwell International, Martin Marietta, and Thiokol.

France, Italy, Russia, and other nations from across the globe will showcase their capabilities and tech transfer opportunities in a special exhibits pavilion, and in a plenary workshop.

The central event of National Technology Transfer Week, Technology 2004 is sponsored by NASA, *NASA Tech Briefs*, and the Technology Utilization Foundation in cooperation with the Federal Laboratory Consortium for Technology Transfer.

For information on attending Technology 2004 and other events of Technology Transfer Week, write in no.526 on the reader response card or call Wendy Janiel at (212) 490-3999.

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Computer Programs

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Mathematics and Information Sciences

Software for Computer-Security Audits

Information relevant to potential breaches of security can be gathered efficiently.

The administrator of security of a VAX/VMS operating system has many software security options from which to choose. Security features available to the administrator include controlling who is allowed to operate in the privileged state of the system, who is allowed to circumvent the security controls of the system how log-on passwords are managed, and how infractions of security are treated. The Automated Auditing Tools for VAX/VMS program was developed by The MITRE Corp. to evaluate the security system of the Johnson Space Center VAX/VMS computers. The program provides an efficient means for gathering the information necessary for a thorough review of security.

The Automated Auditing Tools for VAX/VMS program includes the following automated software tools that perform the noted tasks: (1) Privileged ID Identification — the program can identify users and their privileges to circumvent existing computer security measures; (2) Critical File Protection — critical files that are not properly protected can be identified; (3) Inactive ID Identification— those identifications of users that are no longer in use can be found; (4) Password Lifetime Review — the maximum lifetimes of the passwords of all identifications can be determined; and (5) Password Length Review — the minimum allowed length of passwords of all identifications can be determined.

The Automated Auditing Tools for VAX/VMS program is written in the DEC VAX DCL language and can be executed on any VAX computer running VMS 4.3 or later. "Read" access to SYSUAF.DAT, "execute" privileges for SYSGEN, and "readall" privileges are required to execute the programs. This program is available in DEC VAX backup format on a 9-track, 1,600-bit/in. (630-bit/cm) format magnetic tape (standard medium) or on a TK50 tape cartridge. The program medium includes an electronic copy of the documentation. Automated Auditing Tools was developed in 1989.

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This program was written by Kate Arndt and Emily Lonsford of the The MITRE Corp. for **Johnson Space Center**. *For further information,* ***write in 2*** *on the TSP Request Card.*
MSC-21661

Program Finds Minimal Cut Sets

CUTSETS solves reliability-analysis programs posed as graph models.

Fault-tree and digraph mathematical models are frequently used in analyzing failures of systems. Both types of models represent a failure-space view of the systems, using AND and OR nodes in directed

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graph structures. A fault tree must have a treelike structure; that is, neither cycles nor loops are allowed in such a graph. However, a digraph may contain any pattern of interconnection between nodes.

A common operation performed on digraph and fault-tree models is the calculation of minimal cut sets. A cut set is a set of basic failures that could cause a given (target) failure event to occur. A minimal cut set for a target-event node in a fault tree or digraph is any cut set for the node, such that if any one of the failures in the set is removed, the occurrence of the other failures in the set will not cause the target failure event.

The CUTSETS computer program identifies all the minimal cut sets for a given node. The CUTSETS software package contains subprograms that solve for minimal cut sets of fault trees and digraphs by use of object-oriented programming techniques. These cut-set codes can be used to solve graph models for reliability analysis and identify potential single-point failures in a modeled system.

The fault-tree minimal-cut-set code reads a fault-tree-model input file with each node listed in a text format. In the input file, the user specifies a top node of the fault tree and a maximum cut-set size to be calculated. CUTSETS finds minimal sets of basic events that would cause the failure at the output of a given fault-tree gate. The program can find all the minimal cut sets of a node, or minimal cut sets up to a specified size. The algorithm performs a recursive top-down parse of the fault tree, starting at the specified top node, and combines the cut sets of each child node into sets of basic event failures that would cause the failure event at the output of that gate. Minimal-cut-set solutions can be found for all nodes in the fault tree or for only the top node.

The digraph-cut-set code uses the same techniques as does the fault-tree cut-set code, except it includes all upstream digraph nodes in the cut sets for a given node and checks for cycles in the digraph during the solution process. CUTSETS solves for specified nodes and does not automatically solve for all upstream digraph nodes. The cut sets are put out as a text file.

CUTSETS includes a utility subprogram that converts the popular COD-format digraph-model-description files into text input files suitable for use with the other CUTSETS subprograms. FEAT (MSC-21873) and FIRM (MSC-21860), which are available from COSMIC, are examples of programs that produce COD-format digraph-model-description files that can be converted for use with the CUTSETS subprograms.

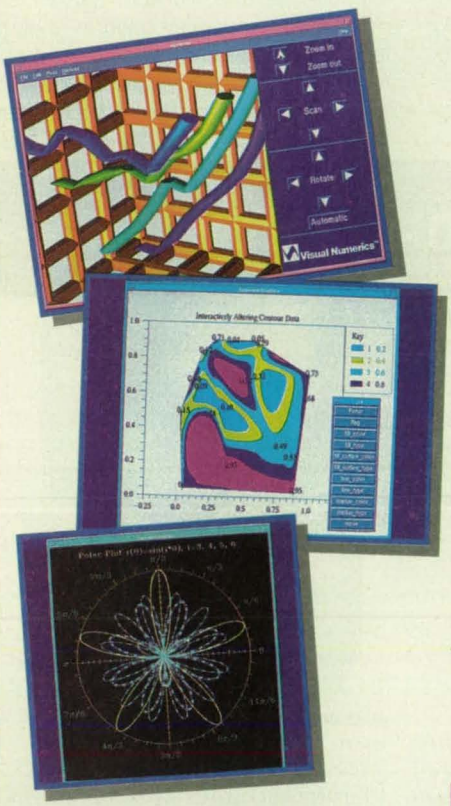
CUTSETS is written in C language to be machine-independent. It has been successfully implemented on a Sun computer running SunOS, a DECstation computer running ULTRIX, a Macintosh computer running System 7, and a DEC VAX computer running VMS. The amount of random-access memory needed varies with the size of the model. CUTSETS is available in UNIX tar format on a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge (standard distribution) or on a 3.5-in. (8.89-cm) diskette. It is also available on a 3.5-in. (8.89-cm) Macintosh-format diskette or on a 9-track, 1,600-bit/in. (630-bit/cm) magnetic tape in DEC VAX FILES-11 format. Sample input and sample output are provided on the distribution medium. An electronic copy of the documentation in Macintosh Microsoft Word format is included on the distribution medium.

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This program was written by D. L. Iverson of **Ames Research Center**. *For further information,* ***write in 38*** *on the TSP Request Card.*
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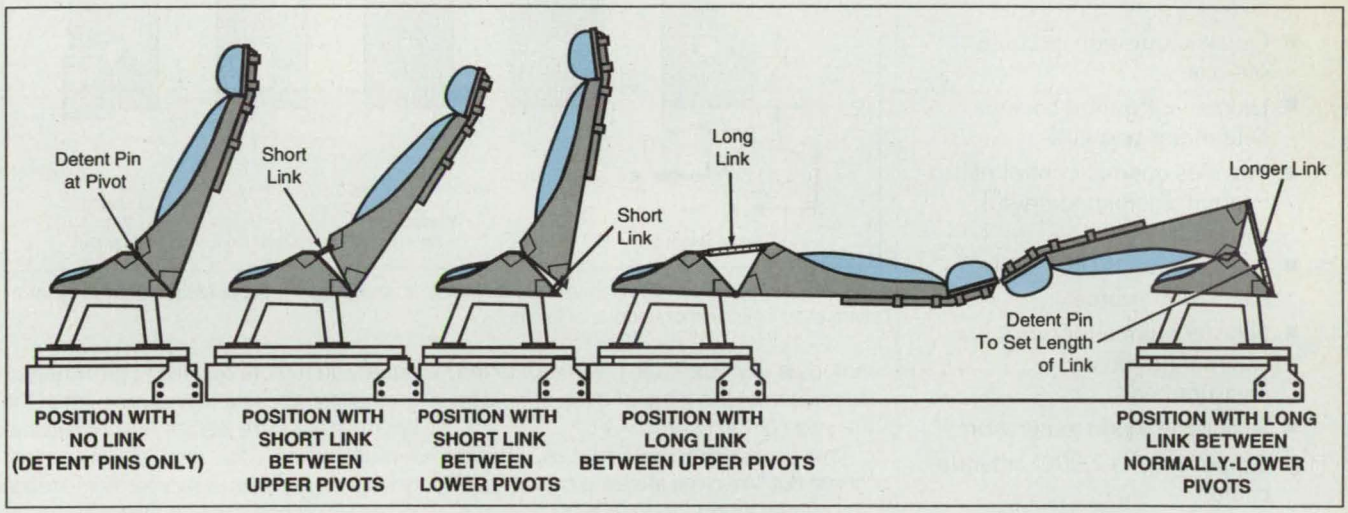
Langley Research Center, Hampton, Virginia

The figure illustrates a multiposition seat that is designed for use in a spacecraft and that could probably be adapted to airplanes and land vehicles. The back of the seat can be pivoted about either of two axes: one axis for folding back to form a bed and a second, higher axis for folding forward to form a compact ottoman, even when the seat is thickly padded.

With its back folded forward, the seat presents minimum obstruction to movement in its vicinity. With the back vertical or nearly so, the seat can be used conventionally as a chair. With the back horizontal, the seat can be used for sleep or to support a weak or injured person.

The back is held in position by links and detent pins that fit into holes in the links. The effective length of each link and, thereby, the angle of the back, are set by selection of the holes into which the pins are inserted — a simple but effective scheme that keeps weight low and avoids the need for complicated mechanisms.

This work was done by Ian O. MacConochie of Lockheed Engineering and Sciences Co. for **Langley Research Center**. *For further information,* ***write in 82*** *on the TSP Request Card. LAR-14646*



Long and Short Links are used to adjust the back of the seat to a variety of positions.

Designing Bolted Joints Between Composite Plates

Basic analyses of stresses in principal modes of failure are presented.

Lewis Research Center, Cleveland, Ohio

Simplified methods have been developed for use in the preliminary design and analysis of bolted joints between flat composite-material plates loaded in tension. The analysis is also applicable to joints between composite and metal plates. The methods are based on approximate equations for the limiting stresses in a single-bolt joint in the five modes of failure that occur most commonly in practice (see figure).

The first is the local-bearing-failure mode, in which a plate fails locally in compression, crushed at the contact with the bolt. The bearing compressive stress is approximated as F/dt_c, where F is the applied force, t_c is the thickness of one of the plates, and d is the diameter of the bolt. To design preliminarily against failure in this mode, one chooses these parameters so that F/dt_c is less than the compressive stress of the composite.

In the second mode of failure, called "net tension," the applied tensile force is deemed to be distributed evenly over a cross-sectional plane that includes the axis of the bolthole. The tensile stress in this plane is approximated as $F/(w-d)t_c$, where w is the width of the plate. In designing preliminarily against failure in this mode, one chooses the parameters to make this stress less than the tensile strength of the composite material.

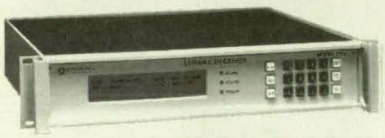
In the third mode of failure, called "wedge-type splitting," a crack opens at the local bearing point and propagates along the plate to a free edge. Failure in this mode is caused by the lateral pressure of the bolt against the bolthole, and occurs when the transverse splitting stress exceeds the transverse tensile strength. The transverse splitting stress is approxi-

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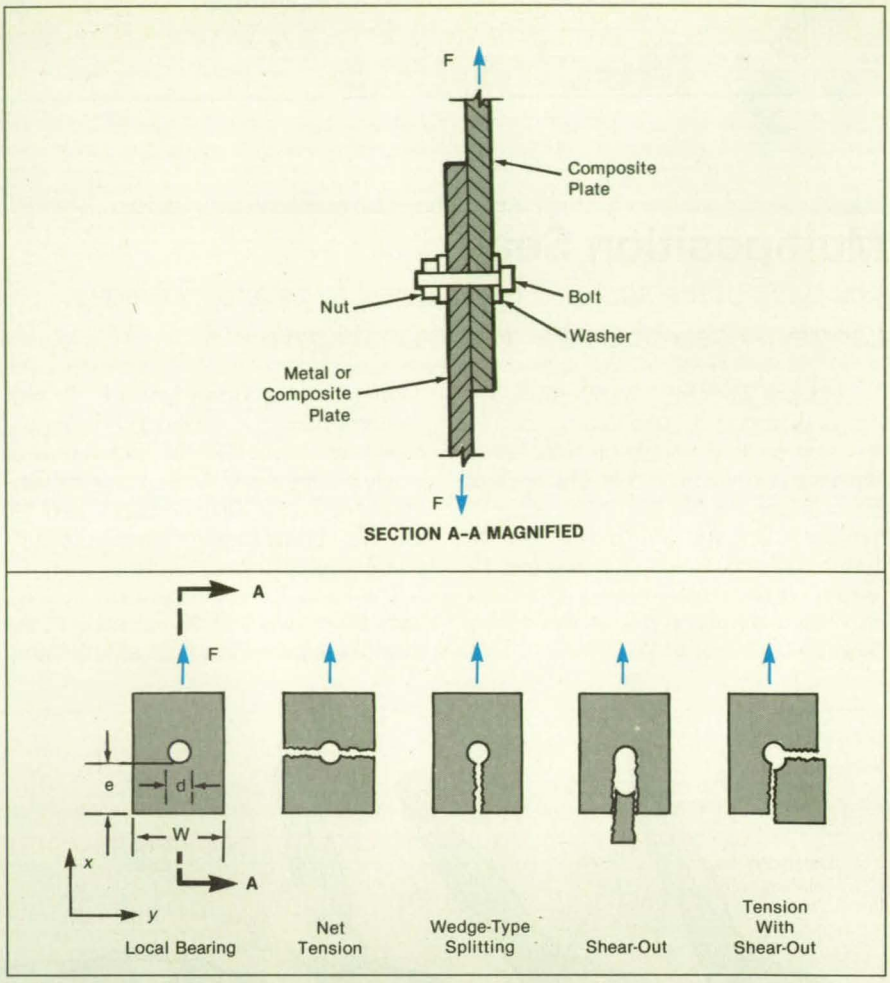


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A Bolted Joint between composite-material plates is analyzed by use of simple equations for the stresses in five common modes of failure.

mated as $2F/[(2e - d)t_c]$, where e is the distance from the edge of the bolt-hole to the edge of the plate.

The fourth mode of failure, called "shear-out," involves shearing on two parallel planes along the load path from the bolt- hole to a free edge of the plate. The shear stress that causes this failure is approximated as $F/2et_c$, and one chooses preliminary design parameters to make this stress less than the shear strength of the plate material.

In the fifth mode of failure, called "tension with shear-out," a chunk on one side breaks off in both tension on a cross-sectional plane and shear on a longitudinal plane. The load that causes failure in this mode is approximated by the equation

$$F = \frac{t_c[(w - d)S_{cxxT} + 2e\,S_{cxyS}]}{2}$$

where S_{cxxT} is the tensile strength and S_{cxyS} is the in-plane shear strength of the plate material.

While a multiple-bolt joint can be analyzed and designed by use of the same equations, one must be careful to allocate the loads correctly among the various bolts. In the traditional first approximation, one assumes that all bolts share the load equally. In a more realistic approximation, the bolts in the first row carry most of the load. In a yet more realistic approximation in a partial worst-case analysis, one might consider the effects of redistribution of loads to remaining bolts after a failure in one of the five modes at a specified bolt. The analysis can be made still more accurate by considering such factors as the transfer of loads through friction, effects of cyclic loading and unloading, effects of heat and moisture, effects of biaxial loading, through-the-thickness compression caused by tightening of bolts, and flatwise local bearing stresses at the edges of bolts, nuts, and washers.

This work was done by Christos C. Chamis of **Lewis Research Center**. *Further information may be found in NASA TM-100281 [N88-15020], "Simplified Procedures for Designing Composite Bolted Joints."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700.
LEW-15380

Cooled Panel With Thermostats in All Passages

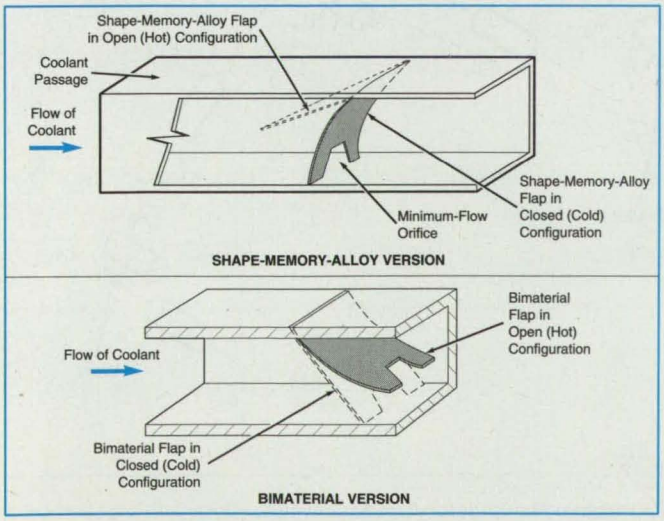
Flows in all passages would be regulated to equalize temperatures.

Langley Research Center, Hampton, Virginia

A simple shape-memory-alloy or bimaterial thermostatic valve would be incorporated in each passage of a multiple-passage cooled panel, according to a proposal. The thermostatic valves would all be set to the same opening/closing temperature, so that they would regulate the flows in all the passages to equalize or nearly equalize the temperature across the panel in the presence of transient, nonuniform surface heating. This simple concept of the combined regulation of flow and temperature could be especially beneficial in an application in which (1) overheating could cause damage and (2) both overcooling and excessive circulation of coolant could occur in the absence of regulation if the cooling capacity of the panel were made large enough to handle the peak heat load. Potential applications include cooled structures for advanced hypersonic aircraft and engines.

Typically, a cooled panel would contain multiple parallel passages. The upper part of the figure shows one such passage of rectangular cross section, in which a simple thermostatic valve in the form of a shape-memory-alloy flap would be incorporated in the downstream end or another suitable temperature-sensing location. The opening/closing temperature of this valve would be the critical transition temperature of the shape-memory alloy: above this temperature, the alloy is relatively strong and stiff; below this temperature, the alloy is relatively weak and flexible. A flap made of this alloy can exert considerable force when it is heated from below to above this temperature and it attempts to return to its original shape.

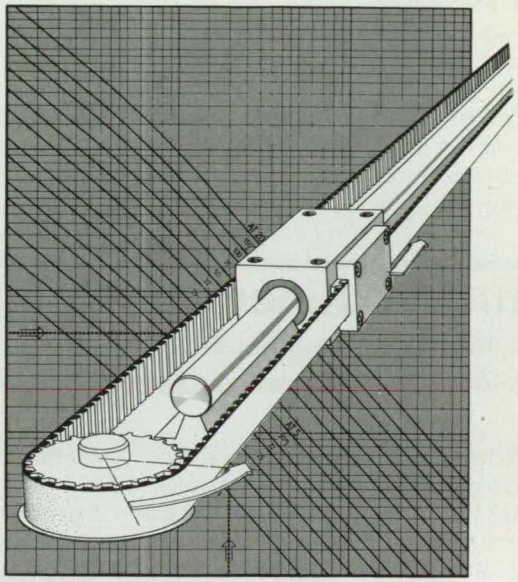
Above the critical transition temperature, the flap would straighten itself out into the open configuration and would be deflected only slightly by the pressure of the flowing coolant. If the temperature in the passage were to fall below the critical transition temperature, the alloy would become flexible, so that the flap would be bent toward the closed configuration by the pressure of the flowing coolant. Thus, the flap would ease or restrict the flow of coolant, respectively, depending on whether the temperature was above or below the critical transition temperature. Optionally,



A **Thermostatic Valve** in the form of a shape-memory-alloy or bimaterial flap would regulate the flow and temperature in each coolant passage.

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Call For Nominations

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Letters of nomination must include the organization's name and address, a contact and phone number, and a 200-300 word description of the commercialized product or process, focusing on its importance (such as its economic or societal impact) and novelty in the marketplace. The description also should highlight the federal government's role in the technology's development and transfer. Up to ten pages of supporting materials may be included with the letter of nomination.

DEADLINE FOR NOMINATIONS IS AUGUST 1, 1994.
Nominees will be notified by September 15, 1994.

MAIL NOMINATIONS TO: Technology Utilization Foundation, 1994 Awards, 41 East 42nd St., #921, New York, NY 10017
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a small orifice could be included in the flap to provide a minimum cross section for flow even in the fully closed configuration.

The bimaterial (e.g., bimetallic) version shown in the lower part of the figure would resemble the shape-memory-alloy version, but it would be oriented to be pushed open by the flow pressure. Unlike the shape-memory-alloy version, it would provide a continuous range of flow cross section over a broad temperature range instead of abruptly opening or closing at a single critical transition temperature; the flap would bend toward the open or closed configuration with an increase or decrease in temperature, respectively. However, the utility of this version may be limited by the conflict between the requirements for (1) stiffness to resist bending under flow pressure (necessitating a thick flap) and (2) large change of curvature with temperature (necessitating a thin flap). Still other versions would involve various combinations of overlapping holes that would be moved relative to each other by differential thermal expansion to change flow cross sections.

This work was done by Max L. Blosser of **Langley Research Center** *and H. Neale Kelly of Analytical Services and Materials, Inc. No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 20].
Refer to LAR-14734

Efficient Kinematic Computations for 7-DOF Manipulators

A configuration parameter called the "arm angle" is used to exploit redundancy.

NASA's Jet Propulsion Laboratory, Pasadena, California

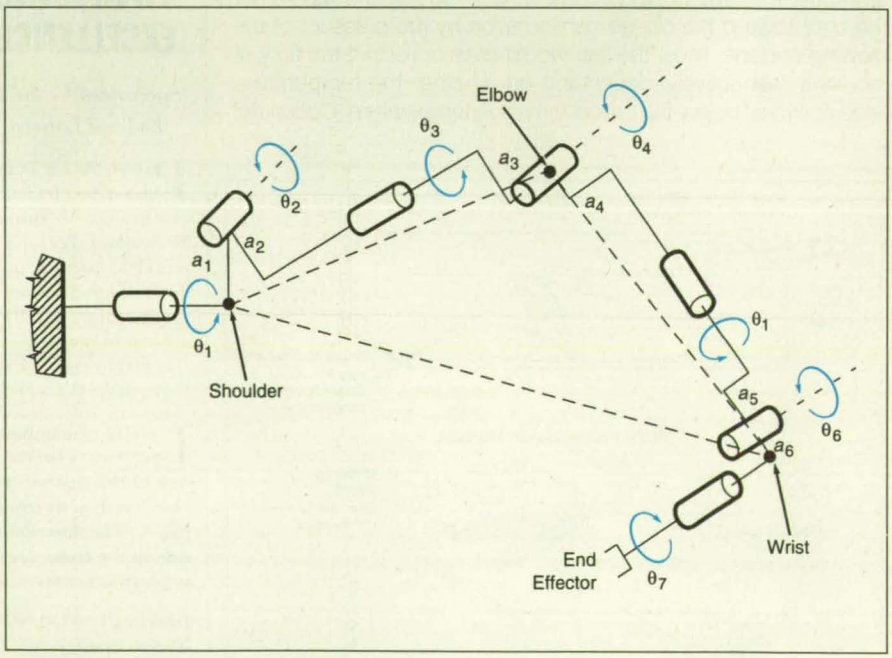
Efficient algorithms for the forward kinematic mappings of a seven-degree-of-freedom (7-DOF) robotic manipulator that has revolute joints have been developed on the basis of representation of the redundant DOF in terms of a parameter called the "arm angle." A 7-DOF manipulator has one redundant DOF because six DOF's suffice to specify the position and orientation of its end effector. The class of 7-DOF manipulators with revolute joints is important because it includes manipulators that have shoulder, elbow, and wrist joints like those of the human arm (see figure).

The present development based on the arm angle is an intermediate product of a continuing effort to exploit the redundancy in a manipulator according to the concept of basic and additional tasks. The concept can be summarized in somewhat oversimplified form as (1) using the nonredundant degrees of freedom to perform the basic task of positioning and orienting the end effector as specified and (2) using the redundant degrees of freedom to perform a simultaneous additional task; e.g., reaching around an obstacle or maintaining a desired posture while positioning the end effector. This concept was also discussed in "Configuration-Control Scheme Copes With Singularities" (NPO-18556), *NASA Tech Briefs*, Vol. 17, No. 2 (February 1993), page 81, and "Increasing the Dexterity of Redundant Robots" (NPO-17801), NASA Tech Briefs, Vol. 14, No. 10 (October 1990), page 88.

The arm angle can be defined as the angle between (1) the plane that contains the shoulder, elbow, and wrist joints and (2) a reference plane that includes the line from the shoulder joint to the wrist joint. The arm angle can be described equivalently as an angle of motion of the elbow about a line from the shoulder to the wrist. Of course, the arm angle is undefined when the arm is held out straight or folded to a configuration in which the wrist and shoulder joints line up.

The forward kinematic mappings from the manipulator-joint angles to the Cartesian coordinates of all of the components of the manipulator. In the arm-angle representation, the forward kinematic mappings become, more specifically, the mappings from the manipulator-joint angles to the coordinates of the end effector and to the arm angle. The differential kinematic mapping maps joint velocities to end-effector and arm angle velocities. The practical significance of the arm-angle representation is that the efficiency of the resulting algorithms can accelerate the kinematical computations — an advantage in the case of a typical redundant manipulator, for which it is necessary to update the kinematic mappings at a rate between 40 and 200 Hz for control. This development also has more general significance in that similar enhancements of the efficiency of computation of the forward and inverse kinematics of any 7-DOF robotic manipulator can be obtained by use of any appropriate redundancy-resolving scalar parameter, which does not necessarily have to be the arm angle.

This work was done by Homayoun Seraji and Mark K. Long of Caltech and Kenneth Kreutz-Delgado of the University of California at San Diego for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 52*** *on the TSP Request Card. NPO-18558*



This **Anthropomorphic Robotic Manipulator Arm** has revolute joints, with a total of seven degrees of freedom (θ_1 through θ_7). Six degrees of freedom are needed to specify the position and orientation of the end effector; the seventh degree of freedom is redundant and can be used for another purpose.

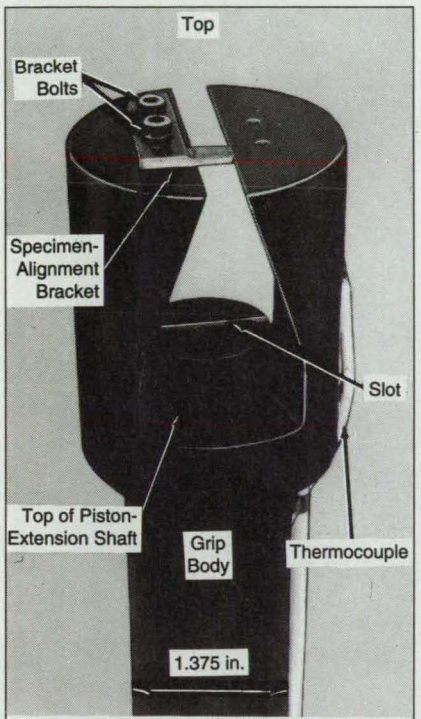
Hydraulically Driven Grips for Hot Tensile Specimens

Temperature-sensitive components are located away from hot zone.

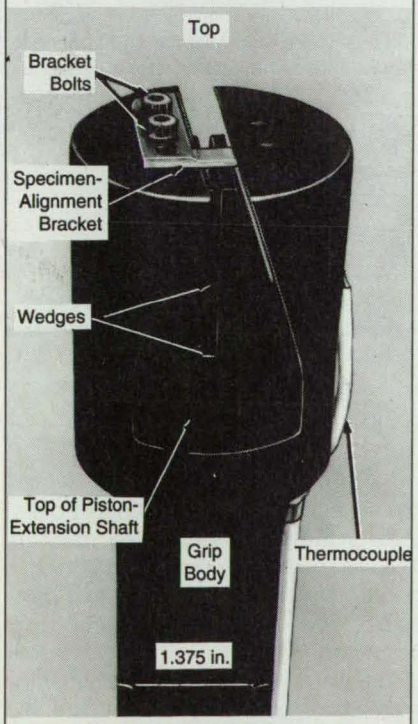
Langley Research Center, Hampton, Virginia

A pair of grips for tensile and compressive test specimens operate at temperatures up to 1,500 °F (about 800 °C). The grips include wedges that hold a specimen inside a furnace, where it can be heated to a uniform temperature. Hydraulic pistons drive the wedges, causing them to exert the clamping force. The hydraulic pistons and hydraulic fluid remain outside the furnace, at room temperature. Cooling water flows through parts of the grips to reduce the heat transferred to the external components.

The top portion of the grip body, called the wedge housing (see Figure 1), resides in the furnace. The grip body is made hollow to accommodate a water-cooled piston extension shaft, which is inserted into



WEDGE HOUSING WITHOUT WEDGES



WEDGE HOUSING WITH WEDGES INSTALLED

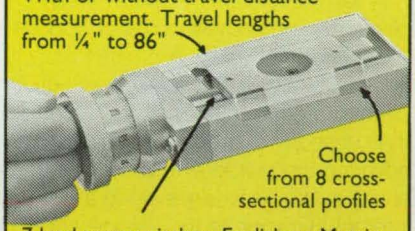
Figure 1. The **Wedge Housing** at the top of the grip body accommodates a pair of wedges that grip one end of a specimen. The piston extension shaft applies force to the wedges to make them grip the specimen.

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the bottom of the grip body and extends into the wedge housing. Slots on the side of the grip body accommodate inlet and outlet connections for cooling water. Threads on the bottom of the grip body mate with the hydraulic-actuator housing.

The bottom of the actuator housing of one of the two grips is attached to the stationary head of the test machine. The other grip is similarly fastened to the loading ram of the test machine.

A technician loads a specimen by slipping each end between a pair of wedges in each wedge housing. A bracket atop the grip body aligns the specimen with the centerline of the machine. The technician then uses the hydraulic control system to advance the piston extension shafts; the shafts push the wedges along the sloped internal surfaces of the wedge housing, thereby clamping the specimen. The hydraulic pressure is regulated to obtain the required clamping force. Figure 2 shows a complete setup with a specimen installed in a pair of grips.

The grips are dimensioned so that they can transfer loads of up to 5,000 lb (22 kN) while fitting in a furnace 22 in. (56 cm) long. The grips are made of a nickel alloy that retains its strength at the maximum operating temperature.

These hydraulic grips offer important advantages over older devices for gripping specimens in high-temperature tests. Unlike in the case of pin-loading grips, there is no need to drill holes in specimens, with attendant stress concentrations that may distort test results. Unlike bolted-clamp grips, these grips maintain a constant gripping force on specimens, unaffected by thermal expansion. Finally, unlike conventional hydraulic grips, these can be heated to the same temperature as that of the specimen, without risk of heating the hydraulic fluid and actuator components.

This work was done by R. Keith Bird of **Langley Research Center** *and George W. Johnson of Analytical Services & Materials Inc. No further documentation is available.*

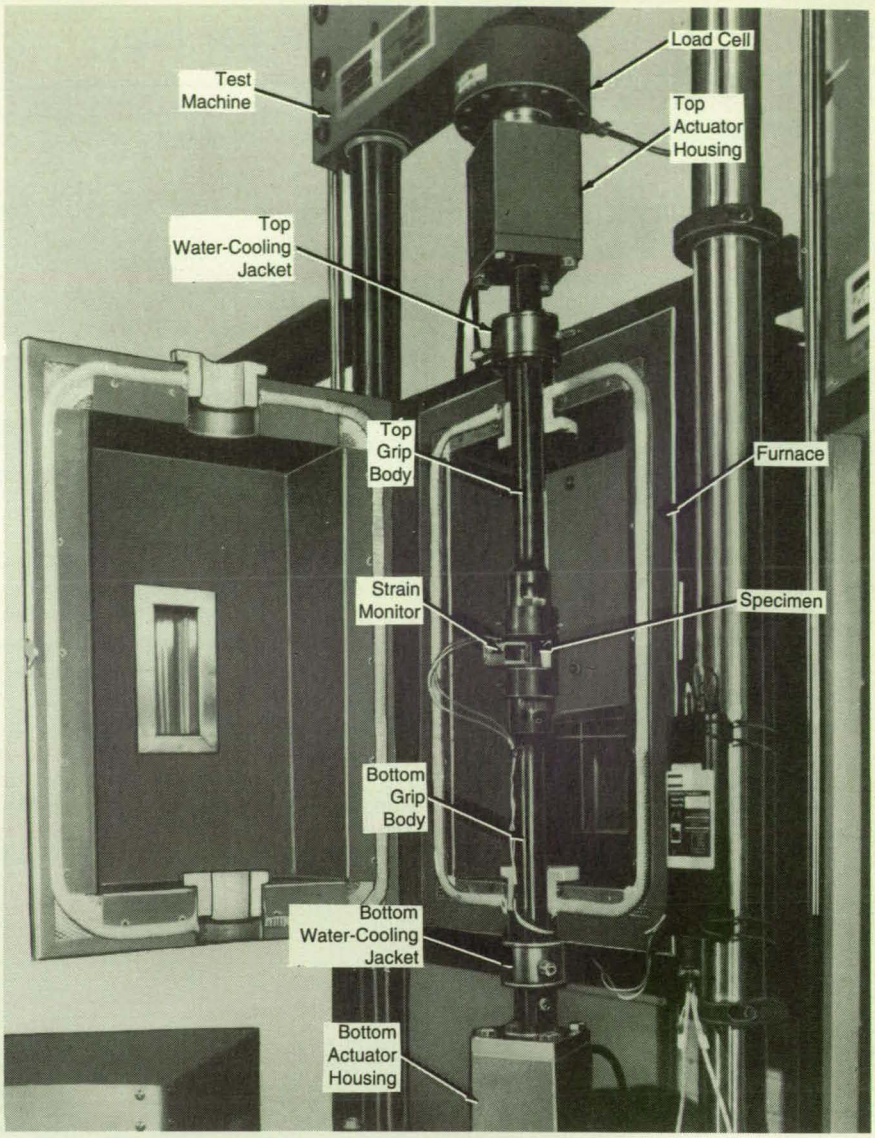


Figure 2. A **Specimen Can Be Loaded** quickly and easily in a test machine and furnace for hot tensile or compressive testing. Once the specimen is loaded, the furnace door is closed and testing proceeds.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 20]. Refer to LAR-14938.

Mechanical Foam Remover

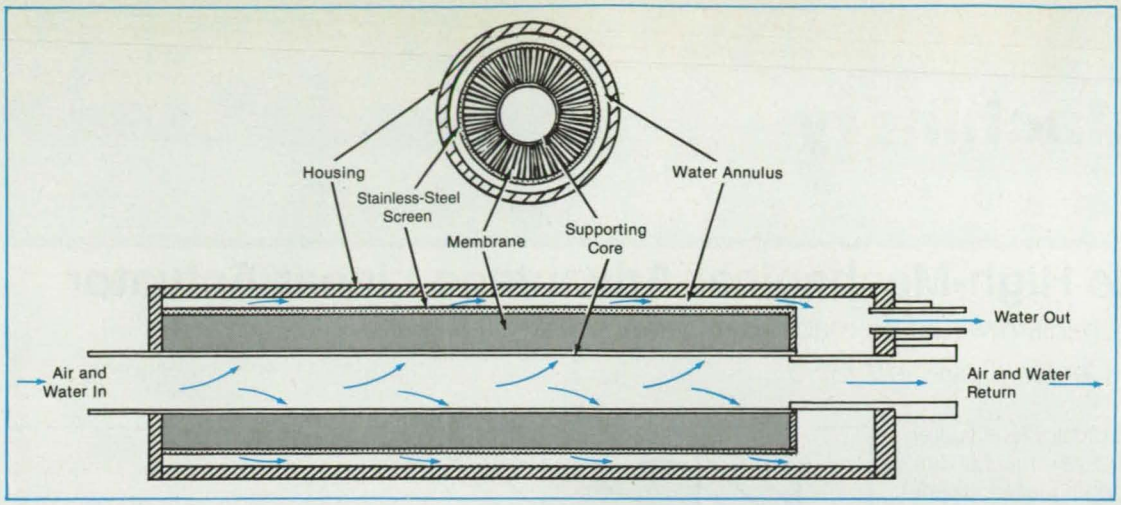
Soap bubbles are removed from wastewater without using chemicals.

Lyndon B. Johnson Space Center, Houston, Texas

A filter removes foam from the soapy water stream discharged by the primary phase separator of a water-reclamation system. The filter uses no antifoam chemicals, which would not only have to be replenished but would also place an added load on a water-reclamation system. The filter contains no moving parts and requires no energy input other than the small energy needed to pump the water through the filter.

The mixture of air and water from the primary unit flows into, along, and radially through the core of the filter (see figure). A porous membrane surrounds the core. Because the membrane is wet, water flows through it much more readily than air does. (This phase selectivity of a wet membrane is used in the "bubble point" test for the integrity of a filter medium. The wet medium is pressurized with air; a good filter contains the air up to a pressure that decreases with increasing size of its pores.)

The water and air that do not enter the membrane flow axially out the core and are returned to the primary separator. The



The **Coaxial Membrane Passes Water Only.** The part of the flow that is not filtered flows along the core and is recirculated.

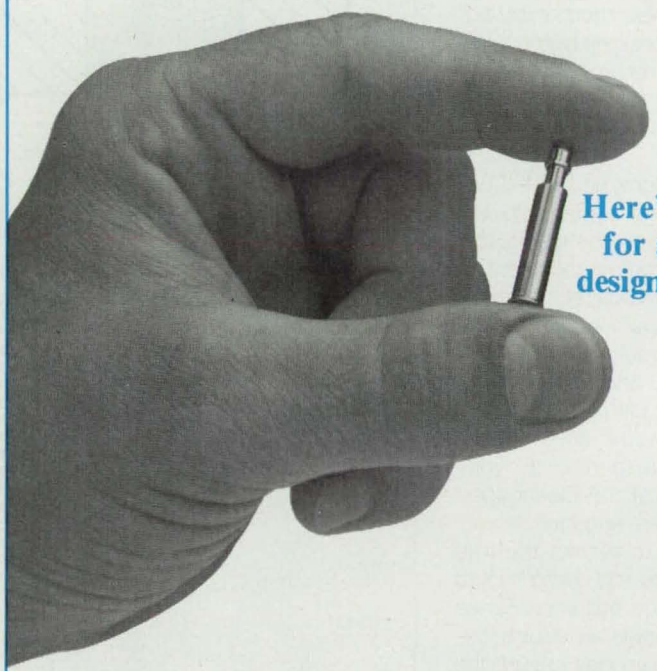
water that flows radially through the membrane contains a little air in solution.

This radial flow enters a relatively-large-pore stainless-steel screen that encircles the membrane. In the screen, the dissolved air comes out of solution as microbubbles. The microbubbles agglomerate into large bubbles in the screen and are swept away by the flow of water through the screen. This partially defoamed flow enters a second, similar but coarser filter (not shown), which removes the bubbles. The resulting clear, air-free discharge flows to a water-processing system, while the bubbly water that emerges along the core is recycled to the primary separator.

This work was done by Neil Streech of Umpqua Research Co. for **Johnson Space Center**. *For further information,* ***write in 5*** *on the TSP Request Card.*
MSC-21850

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Releasable High-Mechanical-Advantage Linear Actuator

A ball-screw mechanism would be made to engage or disengage a piston as needed.

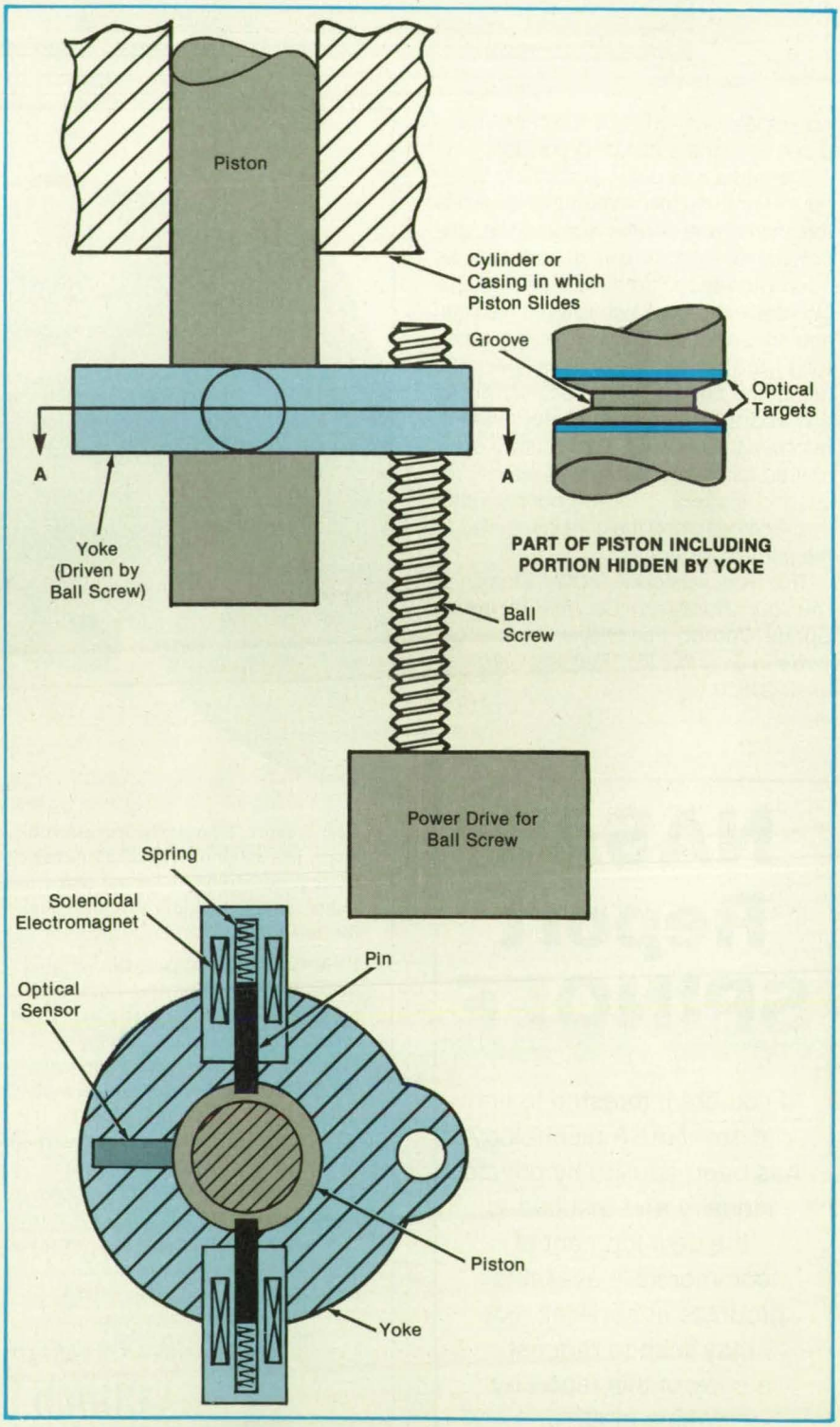
Lewis Research Center, Cleveland, Ohio

A proposed linear actuator (see figure) would include a ball-screw mechanism that would be made to engage or disengage a piston as needed. Heretofore, releasable linear actuators have typically been relatively large solenoidal electromagnets, which have low mechanical advantages and which consume high powers during engagement. The proposed actuator would require low power to maintain release and no power to maintain engagement.

Pins on a yoke on one end of the ball screw would be spring-loaded into engagement with a slot on the piston and would be withdrawn from engagement by turning-on small solenoidal electromagnets. During disengagement, an optical sensor on the yoke would detect optical targets on the piston, and the output of this sensor would be used in a feedback control system that would drive the ball screw in such a way as to make the yoke track the movement of the disengaged piston as though it were engaged.

When it was time to restrict the free movement of the piston and constrain it to move according to the ball-screw-drive command, the solenoids would be deactivated, allowing the springs to push the pins into engagement in the slot on the piston. Spring loading of the pins would also serve as a fail-safe feature in that it would maintain engagement when electrical power was lost.

This work was done by Gordon H. Young of Rockwell International Corp. for **Lewis Research Center**. *For further information,* ***write in 32*** *on the TSP Request Card.*
LEW-15090



Pins Sliding Radially in solenoids in the yoke would engage or disengage a slot in the piston. With the help of optoelectronic feedback, the yoke would be made to follow the free piston during disengagement so that it would always be in position to "grab" the piston.

Powerful Electromechanical Linear Actuator

Advantages include less complexity and less needed maintenance.

Marshall Space Flight Center, Alabama

A powerful electromechanical linear actuator has been designed to replace a hydraulic actuator that provides incremental linear movements to a large object and holds its position against heavy loads. The hydraulic actuator and associated equipment are complicated and vulnerable to leaks, and they need considerable maintenance. This electromechanical actuator is cleaner (because there is nothing to leak) and simpler, and needs less maintenance.

Other electromechanical actuators of similar size and design are available. This electromechanical actuator includes a rotary-to-linear-motion converter. Two brushless dc motors drive a threaded roller-screw shaft via a gear train; a piston attached to a shaft nut travels along the threaded shaft when the shaft is rotated. The two principal innovative features that distinguish the new actuator from prior electromechanical actuators of this type are (1) the use of a shaft-angle resolver (instead of a linear variable-differential transformer) as a source of position feedback to an electronic control subsystem and (2) an antibacklash gearing arrangement.

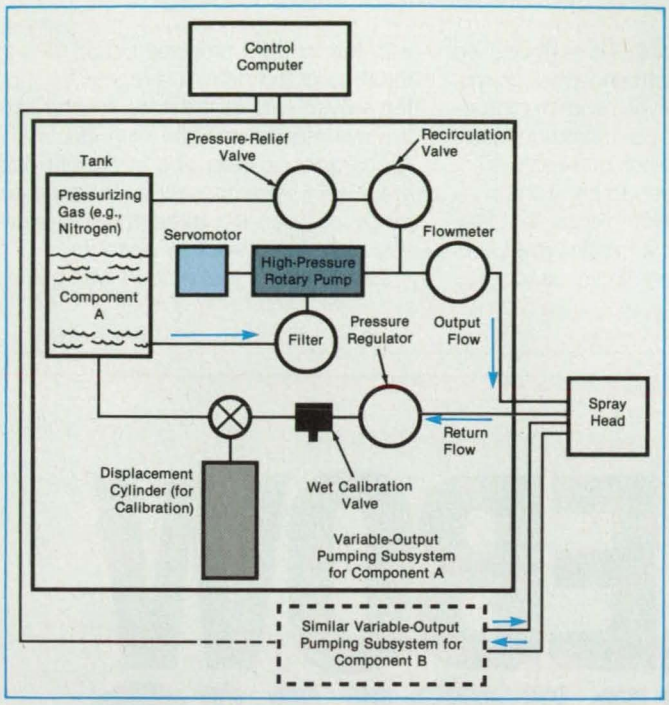
The actuator (see figure) is attached, with spherical bearings at its ends, to the two objects that are to be moved incrementally with respect to each other. Increments of linear motion are monitored and controlled via the increments of angular motion measured by the shaft-angle resolvers and the known relationship (from gear ratios and thread pitch) between rotation and translation. The antibacklash gearing arrangement, which helps to maintain precision of the increments, is implemented in a special fabrication sequence that includes precise machining and small adjustments.

The idler gears, which are parts of the antibacklash gearing, also reduce the speed of rotation of the shaft and increase the torque applied to the output gear. The output gear is keyed to the threaded shaft. The shaft is supported by a quadruplex set of angular-contact ball bearings. Seals prevent the entry of contaminants into the bearings. A linear bearing impregnated with graphite keeps the piston aligned with the axis of linear motion.

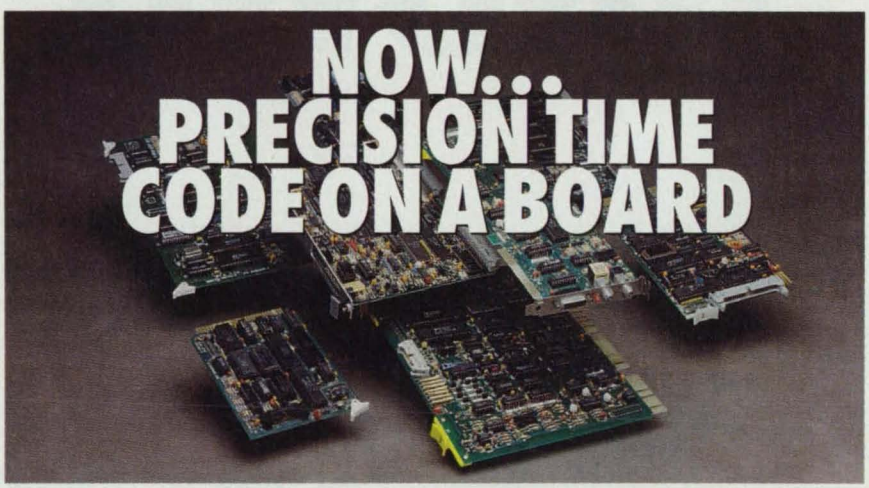
This work was done by John R. Cowan and William N. Myers of **Marshall Space Flight Center**. *For further information,* ***write in 46*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial of this invention should be addressed to the Patent Counsel, Marshall Space Flight Center [see page 20].

Refer to MFS-28673.



This **Electromechanical Linear Actuator** features (1) a rotary-to-linear-motion converter with antibacklash gearing and (2) position feedback via shaft-angle resolvers, which measure the rotary motion.



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Eye/Brain/Task Testbed and Software

The testbed controls, and records the results of, neurophysiological experiments.

Lyndon B. Johnson Space Center, Houston, Texas

The eye/brain/task (EBT) testbed (see Figure 1) records electroencephalograms, the movements of eyes, and the structures of tasks to provide comprehensive data on neurophysiological experiments. The testbed is intended to serve the continuing effort to develop means for interactions between human brain waves and computers. A software library associated with the testbed provides capabilities to recall collected data, to process data on the movements of the eyes, to correlate the eye-movement data with electroencephalographic data, and to present data graphically. As a consequence, cognitive processes can be investigated in ways that were not previously possible.

The design of the testbed was guided partly by previous observations that indicated correlations between cognitive activity related to tasks and visual activity during the execution of the tasks. It was decided to interpret brain waves via those movements of the eyes that are associated with tasks: the eyes indicate cognitive processes, and the tasks provide a context.

At the heart of the testbed is a computer that records positions of the eyes and head, the activity of the brain, and keystroke responses and that controls all aspects of experimental tasks. The data on brain waves are collected by a commercial electroencephalograph. An oculometer mounted on a helmet (see Figure 2) collects the data on the movements of the eyes. A magnetic head tracker measures the location and orientation of the head.

The computer uses a specialized algorithm to process eye-movement data from the oculometer and the spatial information from the magnetic head tracker to obtain the location of the eye with respect to the magnetic source of the head tracker. The algorithm also calculates a three-dimensional vector, the origin of which is at the location of the eye. This represents the line of gaze of the eye. This vector is extrapolated to a point of intersection — called the subject's point of gaze — with the graphical display of the computer.

Another point-of-gaze algorithm enables the experimenter to determine where the subject was looking at any time during the experiment. By processing a window of data on the positions and orientations of the head and eyes, it is possible to study the behavior of the eyes during a specified interval. The eye-analysis software module that contains this point-of-gaze algorithm also contains software filters that remove data on blinks and saccadic (twitching) movements. These functions are necessary to transform the raw eye-movement information into a form in which it can be readily correlated with brain-wave information in a task context.

To calibrate the oculometer, the subject is instructed to look at nine predefined points on the graphical display, and the oculometer records eye-position data during one-half second for each point (30 records per point). From these nine points, the oculometer can extrapolate any location on the screen. The accuracy of calibration has typically been between

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For More Information Write In No. 414

1.0° and 1.5° from the intended point of gaze.

This work was done by Thomas Janiszewski, Nora Mainland, Joseph C. Roden, Edward H. Rothenheber, Arthur M. Ryan, and James M. Stokes of Analytics Inc. for Johnson Space Center. For further information, ***write in 8*** *on the TSP Request Card.*

MSC-21754

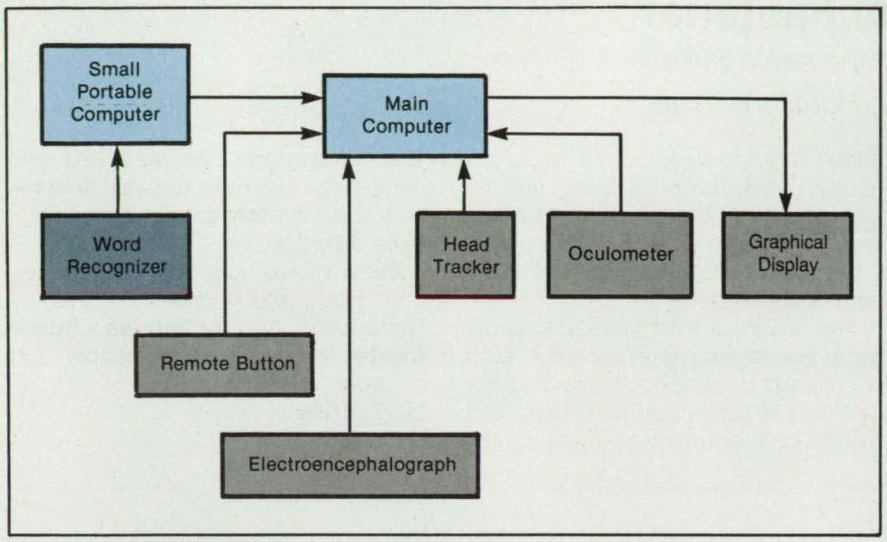


Figure 1. The **Eye/Brain/Task (EBT) Testbed** records and correlates data on movements of the eyes, brain waves, and structures of tasks.

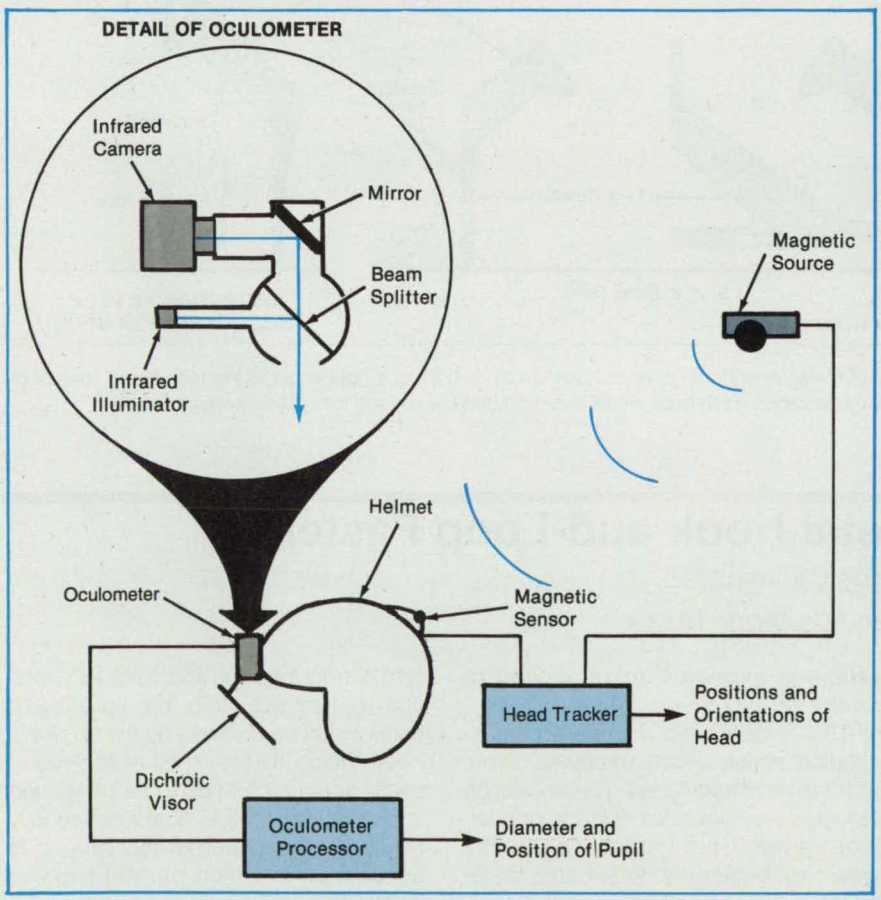


Figure 2. The **Helmet-Mounted Oculometer and Head Tracker** collect data on the movements of the eyes. The eye is tracked by shining a faint infrared beam into the eye to produce a reflection from the pupil and from the surface of the cornea. The head tracker monitors the position and orientation of a magnetic sensor attached to the helmet with respect to a fixed magnetic source.

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Hook-and-Loop Metal Fastener

A conceptual design would overcome strain limitations of metals.

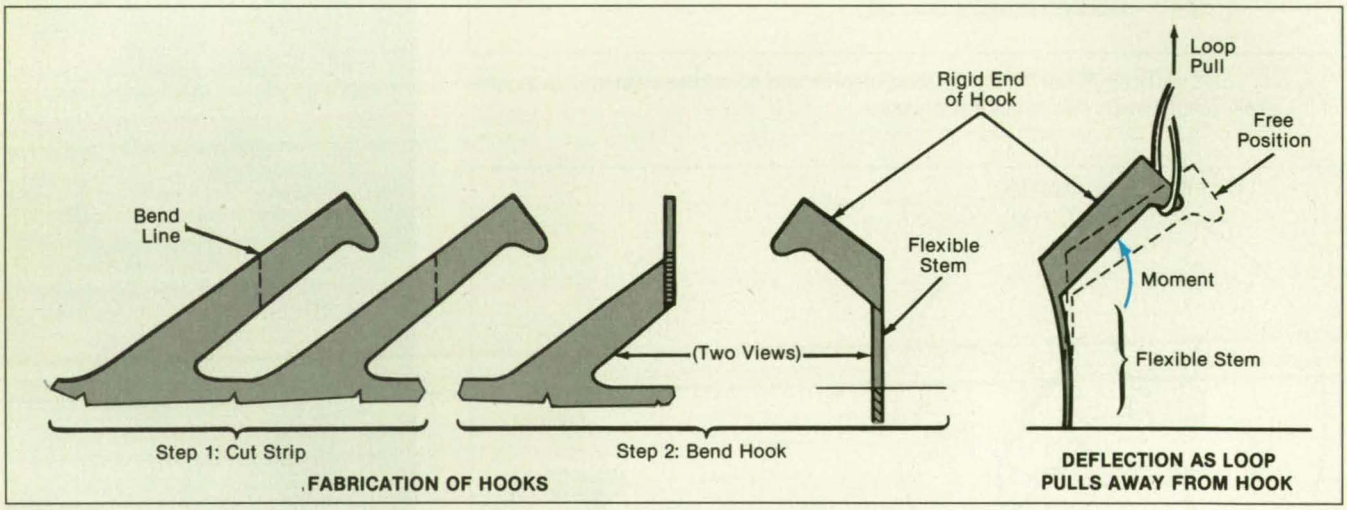
Lyndon B. Johnson Space Center, Houston, Texas

A proposed fastener would include metal loops and hooks that could be repeatedly put together and pulled apart like the familiar Velcro (or equivalent) plastic fastener. Until now, there has been a fundamental obstacle to making metal analogs of plastic hook-and-loop fasteners: metals can tolerate far less elastic unit strain than plastics can (1 percent for metals versus 5 percent for plastics). As a metal loop of conventional design is pulled away from a hook, the hook is greatly deformed, briefly, until the loop escapes. The resulting strain is enough to deform permanently or even break a metal hook the first time a fastener is disengaged.

The design of the proposed fastener would prevent this permanent deformation or breakage by using hooks with rigid tips and flexible stems that both bend and twist as loops are pulled away (see figure). The bending and twisting would take place at the maximum distance from the end of each hook so that stress for a given deflection would be minimized.

This work was done by Bernard Sawaf, J. P. Ross, and Andrew C. Harvey of Foster-Miller, Inc., for **Johnson Space Center**. *No further documentation is available.*

MSC-21586



A **Strip of Hooks** would be stamped from a sheet of metal, and the tip of each hook would be bent at a right angle to the root. Many such strips would be arrayed in parallel to form the hook half of the fastener. Each hook would twist and bend as its loop was pulled away.

Fatigue-Resistant Metal Hook-and-Loop Fastener

Torsion and bending would be largely eliminated.

Lyndon B. Johnson Space Center, Houston, Texas

A proposed metal hook-and-loop fastener could be engaged and disengaged many hundreds of times without breaking. The fastener would have a lifetime much greater than that of other metal hook-and-loop fasteners, which depend on flexure for disengagement [for example, see the preceding article, "Hook-and-Loop Metal Fastener" (MSC-21586)]. The proposed fastener could withstand many hundreds of opening-and-closing cycles, whereas a fastener of the type described in the preceding article is expected to be limited to fewer than 100 cycles.

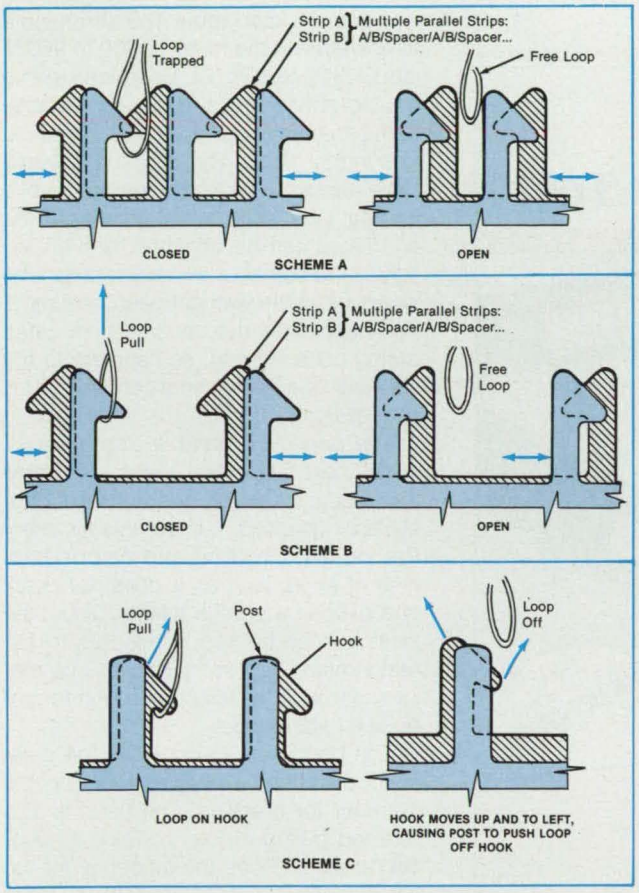
The fastener would open by mechanical action — any of several forms of translation (see figure). The translation would move hooks out of loops or push loops away from hooks. The hooks would not be required to flex and, therefore, would not fail by fatigue.

The figure shows three alternative proposed schemes for locking and unlocking translation. In scheme A, hooks would be spaced so that they would trap loops in the "closed" position. Before actuation, the tip of each hook would be shielded by the tip of the hook facing it. This kind of locking is useful when a part has to be positioned and adjusted several times before it is finally engaged. Somewhat simpler is scheme B, in which parallel rows of hooks would be pushed together to engage hooks. In scheme C, one of an adjacent pair of strips might consist of hooks, and the other might consist of posts. In this case, the movement of the

posts past the hooks would push the loops off the hooks.

A further advantage of the new concept is that little effort would be needed to disengage a fastener. In flexing metal hook-and-loop fasteners, the separation force must exceed the rated maximum load and can be as much as 100 lb/in.^{2} (690 kPa). In the nonflexing version, the major disengagement force would be the minimal one involved in translating the hooks. The maximum load can be quite high, well over 100 lb/in.^{2}.

This work was done by Bernard Sawaf of Foster-Miller, Inc., for **Johnson Space Center**. *For further information,* ***write in 62*** *on the TSP Request Card.*
MSC-21587



Locking and Unlocking Translation is the underlying principle of operation of three versions of the proposed fastener.

Improved Production of Wrought Articles From Powders

Peripheral bands are used in consolidation, forging, and rolling operations.

Langley Research Center, Hampton, Virginia

An improved technique for consolidation of powders into dense articles has been developed in the NASA Langley Research Center powder-metallurgy research program. This technique facilitates the consolidation of dispersion-hardened aluminous powders and composite mixtures for processing to such

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useful wrought articles as plates and sheets.

Methods of consolidation of aluminum powder have included vacuum hot pressing of powders in dies and in cans to full density by use of high consolidation pressures. The present improved technique enables the use of lower consolidation pressures or temperatures and enables fabrication of articles from powders compacted to slightly less than full density.

In the improved technique as in older techniques, the loose powder is first pressed into a semicompacted form (up to about 80 percent of full density) in a conventional cold isostatic press. The powder compact is loaded into a vacuum hot press of conventional nature. Then in a departure from older techniques, a wrought peripheral band or sleeve that fits closely against the wall of the press is added. The band is centered about the height of the compact, using small legs of the band material to position the band above the bottom surface, so that the pressed composite fills the band uniformly. There must be sufficient clearance between the inner surface of the band and the outer surface of the powder for good degassing.

After evacuation and heating, the powder is consolidated by pressing and heating in a double-acting press. In the case of a dispersion-strengthened aluminous alloy, this involves a pressure generally less than 15 kpsi (about 100 MPa) and a temperature in the range of 600 to 950 °F (about 316 to 510 °C). Densification in a double-acting press is usually variable, being maximum at the ram faces and less in the center. By using the wrought band and an appropriate temperature, a compact of 100-percent density at the end faces can be obtained, and an airtight bond can be achieved between the powder and the wrought peripheral band. The band does not become corrugated during consolidation, as happens to the side wall of a can when a canned billet is consolidated.

The peripheral band is also essential in the next fabrication steps — forging and rolling. Inasmuch as the billet is substantially densified, it is suitable for effective induction heating and can be handled in air as long as it does not crack and expose a porous interior. Thus, the billet can be heated in minutes to the temperature necessary to press its major surfaces for sufficient reduction to produce a rollable ingot.

The band acts to constrain the outer fibers of the powder billet, reducing the potential for cracking. The band is also retained during rolling, in which its ductile nature reduces the tendency for the powder alloy article to crack at the edge or split. The band is finally removed in normal edge, head, and tail trim.

One disadvantage of the technique is that it creates mixed alloy scrap. Potential use would be in the production of plates and sheets and perhaps other objects from "hard" powders, particularly from powders, the objects made from which have a propensity to crack when mechanically worked to other forms.

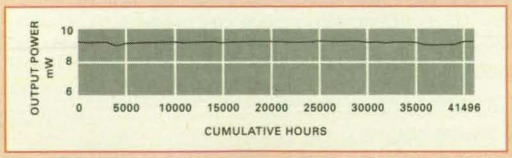
This work was done by James R. Thomas of **Langley Research Center** *and Ogle R. Singleton of Singleton Technology, Inc. For further information,* ***write in 36*** *on the TSP Request Card.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 20]. Refer to LAR-14566.



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Mathematics and Information Sciences

Mapping Between Distinct Reed–Solomon Codes

A decoder can be designed to operate on more than one code.

NASA's Jet Propulsion Laboratory, Pasadena, California

A one-to-one mapping between two Reed–Solomon (RS) codes has been devised to enable a decoder designed for one of the codes to operate on the other one also. The codes in question must have the same N and K parameters (defined below) but can otherwise be two distinct RS codes. The mapping was intended originally to enable the same ground-based decoder to decode telemetry signals from two spacecraft in two different RS codes of $(N, K) = (255, 223)$. The mapping could also be useful in purely terrestrial data communications and in optical and magnetic recording and playback of digitized audio and video signals. In particular, the mapping could be implemented in interface circuitry and/ or software to enable communication between coding systems of different manufacturers that use different RS codes within the same (N, K) family.

RS codes contain redundant data that can be used to correct errors. An RS code is characterized over a finite or Galois field, $GF(2^J)$, where J is the number of bits in a symbol. An RS code word is $N = 2^J - 1$ symbols long; K of these symbols represent the information to be conveyed, while the remaining $N - K$ symbols are check symbols, which are redundant in that they are computed over distinct subsets of the information symbols. The check symbols provide the capability to correct errors in $E = (N - K)/2$ symbols. The elements of $GF(2^J)$ for a given RS code are defined by a Jth degree primitive field-generator polynomial over GF(2), and the code over the particular $GF(2^J)$ is characterized by another polynomial of degree 2E known as the code-generator polynomial.

Consider two RS codes — code 1 and code 2 — of the same (N, K) [equivalently, of the same (J, E)]. Suppose that the decoder is designed for code 1, and it is desired to decode received words that are in code 2 and that may contain erroneous symbols. The mapping involves, first, a succession of linear transformations that convert each received word in code 2 to an equivalent word in code 1. The transformations are derived from the field- and code-generator polynomials. The transformations are performed before decoding, and they do not change the number of erroneous symbols. After decoding, including correction of errors, the inverses of the transformations are applied in reverse sequence to correct the received word. The transformations and their inverses can be incorporated into the decoder via hardware or software.

This work was done by Marvin Perlman of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information,* ***write in 61*** *on the TSP Request Card.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Resident Office–JPL [see page 20]. Refer to NPO-18771.

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Measuring Intracranial Pressure and Volume Noninvasively

An ultrasonic technique may eliminate need to drill into the brain cavity.

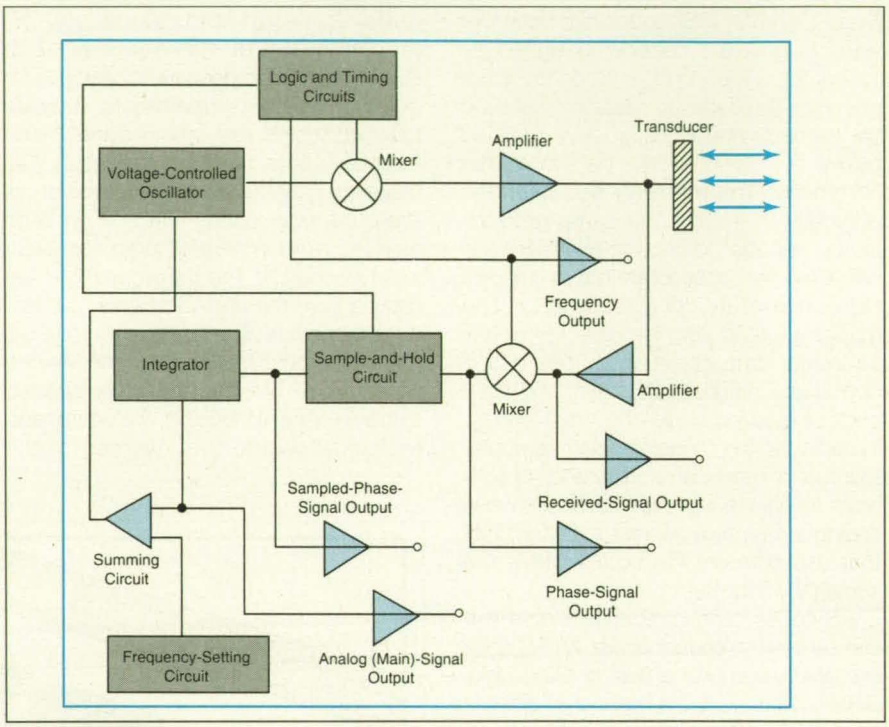
Langley Research Center, Hampton, Virginia

The intracranial pressure (ICP) and the pressure–volume index (PVI) must be monitored for certain patients who have suffered some cranial injury, ischemic event, or other condition. Typically, a hole is drilled into the skull and a catheter with a pressure-sensing device is inserted into the brain to monitor the ICP. To determine the PVI, saline solution is inserted into the cerebrospinal fluid system while the change in ICP is monitored.

The disadvantage of these techniques is that an open wound must be maintained. Because antibiotics are only partially effective in treating cranial infections, the ICP sensor can be left in situ for only 2 weeks or less. After that time, the sensor must be removed to close the wound. Consequently, the physician must try to guess the interval during the patient's treatment when the knowledge of ICP and of the PVI is most needed.

To overcome these disadvantages, a technique has been proposed at NASA Langley Research Center to measure ICP and the PVI by noninvasive techniques. The peak pressure in the cerebrospinal fluid can be determined by use of the intracranial dynamics (ICD) instrument (see figure) to determine the sensitivity of the skull to changes in pressure and by use of a mechanical device to exert an external calibrated pressure on the skull. By monitoring the volume of blood flowing into the jugular vein, one can determine the change of the volume of blood in the cranial system. By measuring the response of the skull to increasing pressure (where pressure is increased by tilting the patient a known amount) and by using cranial blood pressure, one can determine the initial pressure in the cerebrospinal fluid. Hence, the PVI can be determined by noninvasive means. Once the PVI has been determined, the ICP can be determined.

The ICP instrument has been built and tested. The instrument works by sending ultrasound through the cranium and monitoring the ultrasound signal after its traversal. The determinations are based on an equation of state for the cerebrospinal system. By determining the appropriate values in the equation of state, measured acoustical parameters and their evolution in time can be used to determine the significant physiological parameters.



The **Intracranial Dynamics Instrument** probes the cranium ultrasonically to obtain data for the determination of the intracranial pressure and the pressure–volume index.

The voltage-controlled oscillator (VCO) is set close to the resonant frequency of the transducer by the frequency-setting control. The logic and timing circuits send out a gate signal, the width of which is preset. The mixer forms a tone burst, which is sent to the transducer. The transducer sends an ultrasonic tone burst through the skull. This is reflected from the opposite side and is received by the same transducer.

The received signal is amplified, and its phase is compared by a mixer, the output voltage of which is proportional to the deviation of the received signal from quadrature with the signal of the VCO. This voltage is sampled, held, and integrated. The output of the integrator is fed through a summing circuit to the VCO. The frequency of the VCO is changed until quadrature between the output of the VCO and received signal is achieved. The frequency is recorded, and the process repeated. This repetition takes place at intervals of approximately 500 microseconds. As the parameters change within the cranial cavity, the phase of the signal changes, forcing the frequency of the VCO to change. The outputs are monitored to record the changes. From the values recorded, the ICP and the PVI can be determined by calibration of the cranial system to known changes in pressure.

This work was done by John H. Cantrell and William T. Yost of **Langley Research Center**. *No further documentation is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Langley Research Center [see page 20]. Refer to LAR-13894.

Books & Reports

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Machinery

Limit-Cycle Vibrations in Turbomachinery

A paper presents a theoretical study of vibrations in high-speed turbomachinery. This study addresses, among other things, the relationship between two classes of vibrational phenomena that previously have been studied separately: (1) dynamic instabilities, including both those subject to linear analysis and limit-cycle instabilities in cases of nonlinear vibrational response, and (2) subharmonic response to the excitation caused by unbalance of the rotor.

An understanding of this relationship is important because any rotating machine that is operating above a critical speed, has nonlinear restoring forces, has static loads and/or misalignments and has tangential fluid forces can be susceptible to both phenomena.

This work was done by S.G. Ryan of **Marshall Space Flight Center**. *Further information may be found in NASA TP-3181 [N92-14108], "Limit Cycle Vibrations in Tur-bomachinery."*

Copies may be purchased [prepayment required] from the National Technical Information Service, Springfield, Virginia 22161, Telephone No. (703) 487-4650. Rush orders may be placed for an extra fee by calling (800) 336-4700. MFS-27277

Mathematics and Information Sciences

Highlighting Selected Data on Complex Displays

A report describes a study of the effect of highlighting on the speed with which one can search and find information on a complex alphanumeric display. Highlighting gives special emphasis to an item of information, making it stand out from its neighbors. The item can be highlighted by color-coding or by extra brightness, for example.

In the study, 12 human subjects were tested with a variety of information displays in which highlighting, format, and type of data were manipulated. Highlighting was used on 80 percent of the displays, equally divided between valid use (highlighting of the item to be sought) and invalid use (highlighting of a randomly selected item not to be sought). The alternative highlighting modes used in this study were brightness, color, flashing, and reverse video.

This work was done by Marianne Rudisill of **Johnson Space Center** *and Kevin M. O'Brien, Tim McKay, and Kimberly Donner of Lockheed Engineering & Services Co. Further information may be found in NASA TM-104742 [N92-10287], "Display Format, High Validity, and High-light Method: Their Effects on Search Performance."*

Copies may be purchased [prepayment required] from the NASA Center for AeroSpace Information, Linthicum Heights, Maryland, Telephone No. (301) 621-0390. Rush orders may be placed for an extra fee by calling the same number. MSC-22024

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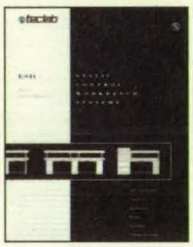


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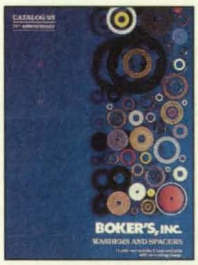


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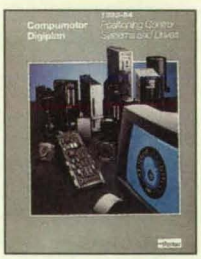
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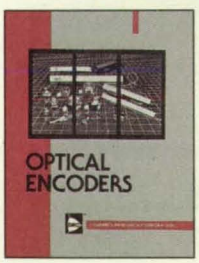


NEW COMPUMOTOR CATALOG! POSITIONING CONTROL SYSTEMS & DRIVES

Compumotor's complete 360 page engineer's guide with specifications, dimensions and performance data presents brushless servos, microstepping motor systems, indexers, linear motors and absolute encoders.

Parker Hannifin Corporation, Computer Motor Division
Phone: 800-358-9070 Fax: 707-584-8015

For More Information Write In No. 307



OPTICAL ENCODERS

DRC's 98 page catalog gives detailed mechanical and electrical specifications for their complete line of rotary, linear, and modular optical encoders. Certain stocked configurations can ship in 3 days. We also specialize in customizing standard models for your specific application.

Dynamics Research Corporation

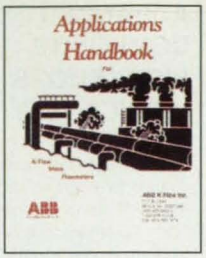
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PROTOTYPING, TEST INTER-CONNECT

Call for a complete range of Interconnect Solutions including hundreds of Prototyping Adapters, Test Probe Adapters for PLCC and Quad Flat Pack, Surface Mountable Test Adapters, Programming Adapters, and other interconnect devices. QUICK TURN CUSTOM DESIGN SERVICE....

Ironwood Electronics
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For More Information Write In No. 310



MASS FLOW METER APPLICATIONS HANDBOOK

The new handbook consists of a series of K-Flow application solutions. The "Application Handbook" illustrates the flow process configuration and ABB K-Flow flowmeter/transmitter systems used in a variety of process applications. Applications covered include Mass (Liquid, Gas, Multi-Component), Density (SG, API, Brix), %Solids, %Liquids, PID, Ratio Blending, Batching, Proportioning, etc.

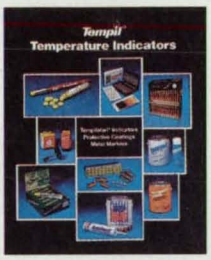
ABB K-Flow
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FLEXIBLE BORESCOPES

Visual inspections can be made easy with the use of a flexible borescope. Machida, Inc.'s new brochure details their complete line of quality flexible borescopes designed for various industrial inspections. Also highlighted are specialized turbine inspection kits, blending borescopes, scopes with channels and working tools, video systems, light sources and borescope accessories. Tel: 800-431-5420.

Machida, Inc.
For More Information Write In No. 312



TEMPERATURE INDICATORS AND MONITORS

This most extensive line of temperature indicating products includes sticks, label monitors, indicating liquids and pellets for preheat/post-heat welding. The 8-page catalog discusses hand test kits, metal markers and protective coatings. Applications cover welding, metal-working, electronics, nuclear and machinery. Tempil Division, Tel: 908-757-8300; Fax: 908-757-9273.

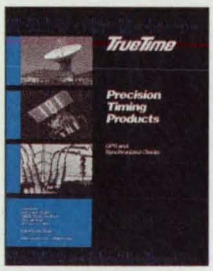
Air Liquide America Corp.
For More Information Write In No. 313



OXYGEN ANALYZERS

A full-color brochure introduces a complete line of oxygen analyzers for the laboratory or process line. They are ideally suited for monitoring the oxygen levels in all types of gas streams. Trace oxygen levels from ppb to 100% are accurately determined by these ruggedly constructed instruments. No periodic maintenance or special operator skills are required. Intrinsically-safe and battery-operated models are also available.

Illinois Instruments Inc.
For More Information Write In No. 314



GPS-SYNCHRONIZED TIMING PRODUCTS

TrueTime's Precision Timing Products catalog features GPS-Synchronized Clocks in rackmount, portable, and board-level configurations. Includes illustrations and product specifications for our complete line of Synchronized Clocks, Time Code Products, and Remote Displays to fit a variety of time and frequency applications.

TrueTime, Inc.
For More Information Write In No. 315



NOISE CONTROL PRODUCTS

New full-line color brochure describes world-leading SONEX and SONEX 1 acoustical treatments. Anechoic shapes provide 400% greater surface area, absorbing sound and eliminating excess noise better than other materials. The brochure highlights new products added to the SONEX line, basic applications, forms, and specifications of SONEX products for effective noise control and acoustic improvement. Tel: 800-662-0032 or 612-520-3620.

illbruck, inc.
For More Information Write In No. 316



ELECTRO-MAGNETIC DESIGN SOFTWARE

The legendary Vector Fields suite of software, including the TOSCA, ELEKTRA and OPERA packages, combines classical finite element techniques with user friendly interactive graphics for high accuracy 2D and 3D simulation and design of all types of electromagnetic equipment.

Vector Fields Inc.
1700 North Farnsworth Avenue
Aurora, IL 60505
Tel: (708) 851-1734 Fax: (708) 851-2106
For More Information Write In No. 317



QUIET COMPRESSED AIR!

Jun-Air's new brochure shows you only a few of the possibilities. Compressors range from oil-lube to oil-less, 110v - DC, 0.25 - 3.0 HP, 0.7 - 11.0 cfm, maximum pressure 120 psi. Vacuum pumps and custom designed compressors to customer specifications also featured. Join over 250,000 satisfied customers in over 50 countries worldwide enjoying their Jun-Air compressors. Ask about our line of "Quiet" compressors. Phone 800-4JUNAIR.

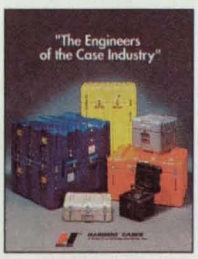
Jun-Air USA Inc.
For More Information Write In No. 318



CLAMPS

The World of Clamping Catalog 492 describes and illustrates toggle and special clamps with vertical and horizontal hold-down, straight-line, latch and squeeze action. Spacing products, hydraulic devices, and CAD database are covered along with applications. De-Sta-Co, Troy, MI. Tel: 313-589-2008.

De-Sta-Co
For More Information Write In No. 319



Hardigg Cases offers over 225 standard rotationally molded transit cases, including a full line of 19" EIA rack mount cases, deck cases, and flange-mount cases. Hardigg's expert engineering, manufacturing, and test facilities provide start to finish custom design capability. A complete list of standard cases allows for rapid delivery...as few as three working days! Take advantage of over thirty years of experience...design a Hardigg case into your next project!

Hardigg Cases
Tel: 1-800-JHARDIGG; Fax: 413-665-8061
For More Information Write In No. 320

UTILITIES FOR COMPUTER VISION





Two Program Libraries for CADDS-4X and CADDS 5. One has 1000s of fasteners and other parts for 3D models, plus AUTOMATIC BILL OF MATERIALS GENERATION. The other has 18 programs, integrated with layer lists. Full DEMO programs are available.

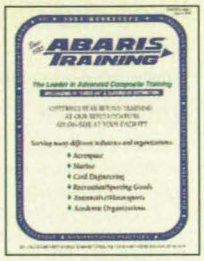
Design Solutions Software Co.
20 Concord Creek Rd., Glen Mills, PA 19342
Tel: 610-358-4054
For More Information Write In No. 321



NEW! OPTICAL REFERENCE CATALOG

Edmund Scientific's free 220-page, full-color annual reference catalog features one of the largest selections of precision off-the-shelf optics and optical instruments, plus a complete line of components and accessories for both large volume OEM users as well as smaller research facilities and optical laboratories. It contains over 8,000 hard-to-find items, including a large selection of magnifiers, magnets, microscopes, telescopes, and accessories. Tel: 609-573-6280.

Edmund Scientific Co.
For More Information Write In No. 322



ADVANCED COMPOSITE WORKSHOPS —SINCE 1983

The brochure describes eleven "hands-on" workshops in advanced composite materials technology. These workshops cover fabrication, repair, manufacturing, tooling, blueprint reading, adhesive bonding, engineering design for specialized repairs, and ultrasonic inspection of composites. Emphasis is on prepreg carbon and aramid fiber materials and processes. REFRESHER WORKSHOPS OFFERED. Call toll-free: 1-800-638-8441. Fax 702-827-6599.

Abaris Training Resources, Inc.
For More Information Write In No. 323



HIGH POWER "SMART" ELECTRIC ACTUATORS

New linear actuators are driven by TERFENOL-D magnetic shape change metal. Low voltage controls linear or oscillatory motion. "Smart" actuators can simultaneously drive and sense with high accuracy and broad bandwidth. OEM and standard systems available. ETREMA Products, Inc. 2500 North Loop Drive, Ames, IA 50010. Tel: 800-327-7291; Fax: 515-296-7168.

ETREMA Products, Inc.
For More Information Write In No. 324

QUICKSTART™ SOFTWARE CUTS DEVELOPMENT TIME



QuickStart™ software from Berkley Process Control eliminates development costs associated with machine control system startup and configuration, motor tuning, and hardware diagnostics by providing these standard functions on powerup. Designed for the multi-axis Bam™ Series-64 Machine Controller, QuickStart's facilities can provide intuitive touch screen operation for a wide range of industries.

Berkley Process Control
For More Information Write In No. 325



THERMOCOUPLE MONITOR/ SCANNER

The SR630 is a 16 channel thermocouple monitor for B, E, J, K, R, S, and T type thermocouples. Temperature can be read with 0.1 degree resolution, or each channel can monitor DC voltage with 1 mV resolution. Any or all channels can be scanned and alarm limits can be set for monitoring temperature deviation. RS-232 and GPIB (IEEE-488) computer interfaces as well as a Centronix printer port are standard. SR630 Thermocouple Monitor US List Price $1495. Tel: 408-744-9040.

Stanford Research Systems
For More Information Write In No. 326



PRESSURE TRANSDUCERS/TRANSMITTERS

Taber pressure transducers/transmitters are outlined in a new brochure. They are available in low and high models in a variety of pressure ranges. Differential transducers provide high differential overload pressure and high line pressure capability. Oceanographic transducers are completely submersible, highly accurate pressure sensors. For more information contact: John Pinder. Tel: 800-333-5300.

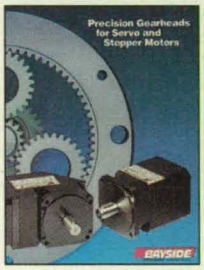
Taber Industries
For More Information Write In No. 327



ELECTRONIC HARDWARE CATALOG

Broadest selection of hardware for electronic assemblies. 350-page free catalog includes a full range of standoffs, captive screws and nuts, chassis fasteners, handles, ferrules, spacers and washers. Special sections—new, unusual products, metric information and Mil-plating specifications. Full inventory, fast turnaround, samples. Tel: 1-800-237-0013; Fax: 201-661-3408.

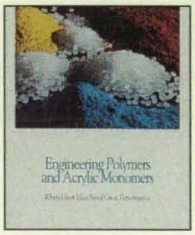
Accurate Screw Machine Co.
For More Information Write In No. 328



GEARHEADS GALORE

22-page catalog has complete technical information on full line of precision gearheads for servo and stepper motors. Low backlash, high torque planetary and right-angle designs are available in ratios from 3:1 to 100:1, with torques up to 15,000 in-lbs. The catalog features drawings, cutaway views, and application notes. Mounting kits are available for any motor.

Bayside Controls Inc.
Tel: 516-484-5353. Fax: 516-484-5496.
For More Information Write In No. 329



POLYMERS & ACRYLIC MONOMERS

A new, 12-page four-color brochure titled "Engineering Polymers and Acrylic Monomers." Included are polymers and monomers family of products, including Rilsan® 11 and 12 polyimides; Rilsan® powder coatings, Pebax® thermoplastic elastomer resins, Platamid® and Platherm® hot melt adhesives; Platilon® hot melt film, and acrylic monomers. Product description, background, and a sampling of applications are also provided.

Elf Atochem North America, Inc.
For More Information Write In No. 330



FREE ENCLOSURES CATALOG

More EMI/RFI shielded cabinets are offered. Shielding effectiveness test data have been revised. Earthquake reinforced enclosures have been added. New dual dimensioned technical drawings in this 300+ page catalog on modular cabinets, sloped front consoles, electronic desks, computer furniture and instrument cabinets. Selections for express shipping in five days. Catalog #500-5 is available in print version or as an IBM-compatible software program.

Equipto Electronics Corp.
For More Information Write In No. 331



NEW PORTABLE OSCILLOGRAPH

Yokogawa's ORM1200 packs power in lightweight, rugged packaging. Isolated inputs accept thermocouple or AC/DC Voltage to 350 VAC with 100 kHz sampling. Review data or set-up the recorder with the user interactive display. Analyze data on the recorder, or PC, via the built-in memory. On-board FDD simplifies data transfer to PC optional features: Logic Inputs, R5-232C, or GPIB, DC Power.

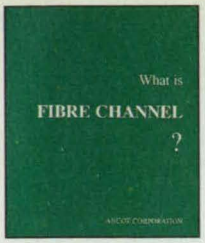
Yokogawa Corporation of America
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SEND FOR LABCONCO'S BIGGEST, MOST COMPLETE PROTECTOR® HOOD CATALOG EVER

Use this 92-page source book to gather information on by-pass, auxiliary-air and variable air volume hoods as well as base cabinets, work surfaces blowers and ductwork. Read about safety accessories such as the Guardian™ Air Monitor. Call 800-732-0031.

Labconco
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WHAT IS FIBRE CHANNEL?

Free! Ancot Corporation's painless introduction to the exciting world of FIBRE CHANNEL. Over 30 pages of the latest ANSI standards for computer channels, communications networks, topologies, protocols, functional levels, performance, and a bibliography! Call Ancot Corporation at 415-322-5322 or fax at 415-322-0455.

Ancot Corporation
115 Constitution Drive, Menlo Park, CA 94025
For More Information Write In No. 334



ELECTRONIC HARDWARE CATALOG

Globe's Free 240-page catalog details their comprehensive line of electronic hardware including: handles, ferrules, jack screws, standoffs, spacers, captive panel screws, panel screw retainers, thumb screws, shoulder washers and many more. Available in American or Metric standards with over 40 protective finishes. Globe Electronic Hardware, 34-24 56th Street, Woodside, NY 11377. Tel: 800-221-1505; in NY 718-457-0303; Fax: 718-457-7493.

Globe Electronic Hardware
For More Information Write In No. 335



10- TO 30-CHANNEL PORTABLE RECORDER

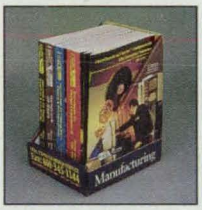
Astro-Med's new 30-channel field recorder with internal battery, built-in bright monitor, 1.44 MByte floppy disk drive, 1.2 MByte RAM per channel, and laser-quality print resolution is described in an illustrated 10-page brochure. The unit, called the Dash 10, offers a host of outstanding capabilities that make it today's most advanced portable recorder. Tel: 1-800-343-4039. Fax: 401-822-2430.

Astro-Med, Inc.
For More Information Write In No. 336



A new series of Super-Fast-Lead ball screw assemblies that feature precision ground accuracy with super high-speed travel rates are now being offered by Ball Screws & Actuators Co. Travel speeds of up to an unheard of 138 inches/second are now achievable combined with high accuracy and repeatability. Stroke lengths are available to 52 inches. The new series is offered completely assembled with end bearing housings—ready to "bolt down and go" or with custom ends machined per print. Tel: 800-882-8857 or 408-629-1132. Fax: 408-629-2620.

Ball Screws & Actuators Co.
For More Information Write In No. 337



FREE DRIVE COMPONENT LIBRARY

Features over 52,400 off-the-shelf inch and metric, commercial and precision small drive components. These 5 new catalogs include technical specifications for over 13,000 gears (D190); 7,900 shafts, bearings and couplings (D200); 18,300 timing belt drives (D210); 9,400 design components (D220); and Fairloc® hub fastening components (D240). Stock Drive Products/Sterling Instrument, 2101 Jericho Tpke., Box 5416, New Hyde Park, NY 11042-5416. Tel: 516-328-3300; Fax: 516-326-8827.

Stock Drive Products/ Sterling Instrument
For More Information Write In No. 338

CROSSED ROLLER SLIDES



These compact crossed roller slides are interchangeable with our ball slide assemblies. Featuring high capacity roller bearings alternately crossed at 45 degrees riding on hardened and ground flat bearing surfaces, these slides exhibit eight to ten times the load capacity and five times greater accuracy than ball slides. Stainless end caps and positive internal stops are standard. Model RD-1 is the smallest commercially available crossed roller slide assembly. All models available from stock. For a forty page product guide please call: 1-800-245-5013. Fax: 203-778-2721, or write Del-Tron Precision, Bethel, CT 06801.

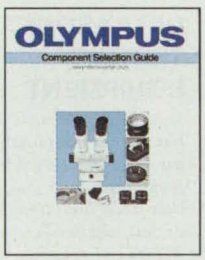
Del-Tron Precision
For More Information Write In No. 339



PCMCIA MEMORY CARDS AND ACCESSORIES

The PCMCIA 68 pin standard is the newest technology in data storage and I/O for Mobile computer. Envoy Data has compiled the latest products in its new catalog. Typical products are: SRAM, FLASH, and Hardrive memory cards; Fax/Modem, LAN, Serial, GPS I/O cards; Reader/Writer card drives; PCMCIA accessories. Technical support and data sheets are also available.

Envoy Data Corporation
For More Information Write In No. 340



COMPONENTS FOR OPTO-MECHANICAL APPLICATIONS

Olympus' world-renowned infinity-corrected optics are combined with ergonomically designed microscope components to provide ideal combinations to meet application requirements. Because Olympus microscopes are modular, users can select complete sub-assembles or their separate components, including: microscope bodies, focusing mounts, observation tubes, revolving objective turrets, stages, and illuminators. Tel: 800-446-5967; Fax: 516- 222-7920.

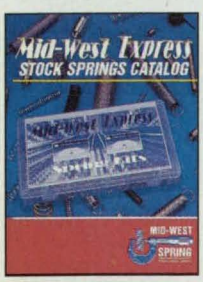
Olympus Corporation
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COMPACT, PORTABLE THERMOCOUPLE CALIBRATOR

4-page brochure now available on the Guildline 5210 thermocouple calibrator/simulator. Accommodates 10 types of thermocouples. DC voltages can be measured or generated in three ranges up to 1.5 volts. Multiple menus allow selection of temperature scale characterization, choice of five languages. "5210 costs less than half of other instruments of this type."

Guildline Instruments, Inc.
For More Information Write In No. 342



MID-WEST EXPRESS 56-PAGE STOCK SPRINGS CATALOG

New catalog describes over 1,500 different stock springs and spring kits available for immediate delivery. The catalog simplifies ordering and contains specifications, price list, order blanks and other helpful information. Compression, torsion, continuous, hot wound, die, extension and specialty springs are described. Tel: 800-346-1400. Fax: 708-739-6622.

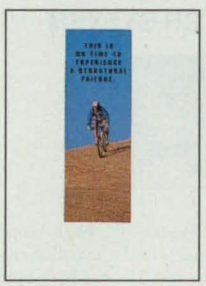
Mid-West Express,
a division of Mid-West Spring Manufacturing Company
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ADHESIVES/ SEALANTS/ COATINGS

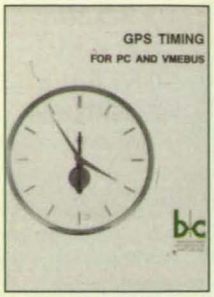
Master Bond, Inc. manufactures over 3000 grades of adhesives, sealants, and coatings. Line consists of epoxies, anaerobics, cyanoacrylates, silicons, and acrylics. Both one- and two-part systems. Systems are designed to meet specific requirements. One-on-one assistance available with our highly knowledgeable technical staff. Tel: 201-343-8983; Fax: 201-343-2132.

Master Bond, Inc.
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SHAPE OPTIMIZATION MADE SIMPLE, FAST AND AFFORDABLE

Put your designs in the hands of COSMOS/M and with a few short iterations, they can lose the weight but still handle the heavy work load. Minimize cost or weight fast while satisfying design constraints such as stress, temperature, frequency or buckling. Features powerful modeler, automatic mesher, fast solver, and a powerful postprocessor all within an easy to use interface. Start optimizing for as little as $995. Call 310-452-2158 in the west or 412-635-5100 in the east.
For More Information Write In No. 345



GPS TIMING FOR PC VMEBUS

This information folder from Bancomm describes new PCbus and VMEbus board-level Global Positioning System (GPS) Satellite Receivers. These products provide worldwide precision time (100 nanosecond) and frequency (1 part in 10E7) references inside the host computer.

Bancomm

For More Information Write In No. 346



TRANSMISSIVE/REFLECTIVE WORKSTATION

Increase throughput and quality levels for both color and B&W film imagery with gordon's free-standing, digitizing work console. Gordon's exclusive PLANNAR light source features: 3200 K quartz halogen lighting, ±5% flatness of field (no hot spots) and a dc power supply.

gordon instruments
Tel: 800-333-2672

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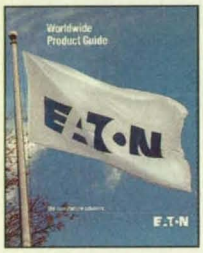


LIGHTWEIGHT MAGNESIUM ALUMINUM CASTINGS

Brochures describe unique prototype, pre-production and production capabilities of this modern foundry. Quality system complies with ISO 9000, automotive, aerospace and government specifications. Uses sand, Investocure, gravity, die and squeeze processes. Offers both low and high volume SPC controlled production. Complete in-house laboratory and testing facilities. Call 216-581-9200. Fax: 216-475-6611.

Thompson Casting Co., Inc.

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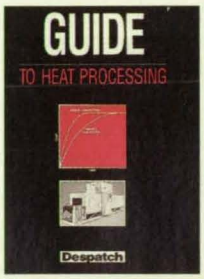


WORLDWIDE PRODUCT GUIDE

The guide from Eaton Corp. contains a comprehensive listing of products, services, and facilities. Eaton manufactures **Vehicle Components** for light, medium and heavy duty trucks, passenger cars and mobile equipment; and **Electrical & Electronic Controls** for aerospace, appliance, automotive and commercial applications and electric power management controls. Tel: 216-523-4400; Fax: 216-479-7014.

Eaton Corporation

For More Information Write In No. 349



GUIDE TO HEAT PROCESSING

Guide to heat processing discusses general issues related to selecting an industrial oven for heat processing. Sections include information on oven construction and loading openings, heat-up/cool-down times, temperature uniformity, types of airflow, material handling, and electrical requirements. Design considerations in hazardous areas are discussed. Tel: 612-469-5424; Fax: 612-469-4513.

Despatch

For More Information Write In No. 350



MOTION MANAGEMENT™ FOR PACKAGING PRODUCTIVITY

New capabilities brochure explains benefits of Pacific Scientific motors, control and the value-added motion management™ approach. Presents cost/performance, adaptability, JIT and QA solutions. Pacific Scientific, Rockford, IL. Tel: 815-226-3100; Fax: 815-226-3080.

Pacific Scientific

For More Information Write In No. 351



ULTRA-HARD MATERIALS FABRICATION

Insaco's brochure describes the custom manufacture of components in sapphire, ruby, quartz, ceramics of all types including glass-ceramics, alumina, zirconia, carbides, and nitrides. The company routinely fabricates these materials for applications in optics, chemistry, vacuum, bearings, electronics, nuclear, space and medicine. Tolerances are measured in millionths of an inch with surface finishes in angstroms and flatness to fractions of a wavelength. Tel: 800-959-0264; Fax: 800-959-0267.

Insaco, Inc.

For More Information Write In No. 352



ULTRASONIC TESTING EQUIPMENT

StressTel Corporation offers a complete portable line of ultrasonic thickness gauges, corrosion gauges, bolt stress measurement devices, ultrasonic transducers and software for nondestructive testing. Thickness gauges range from our simple to use T-Mike EZ to sophisticated T-Scope DL. The Bolt Mike SMII bolt monitoring systems ensures accurate bolt tensioning in any application. Tel: 408-438-6300. Fax: 408-438-7917.

StressTel Corporation

For More Information Write In No. 353



PRECISION LINEAR COMPONENTS

Featuring a wide range of linear devices in a variety of materials, this 32 page brochure is the latest from Berg. Designed to complement the Inch and Metric catalogs it contains Linear Slides, Lead Screws, Linear Bearings and various Mounting Accessories. All designed and manufactured to meet the exacting demands of modern industry.

W.M. Berg Inc.
Tel: 516-596-1700; Fax: 516-599-3274.

For More Information Write In No. 354

NEW SWITCH SYSTEM



Keithley introduces the Model 7002 High Density Switch System, a 400-channel, 10-slot mainframe that can test up to 140 devices/second. The switch is compatible with more than 30 switching cards, enabling the user to test from 10fA to 5A, 30nV to 1.3kV, and DC to 500MHz. Keithley Instruments, Inc., 28775 Aurora Road, Solon, OH 44139. Tel: 800-552-1115; Fax: 216-248-6168.

Keithley Instruments

For More Information Write In No. 355

NEW HIGH PERFORMANCE ELECTROMETER



Keithley introduces the Model 6512 electrometer, with 5fA of input bias current, <1mV of burden voltage and >200TΩ input impedance. It offers a full span of measurement ranges: current from <2fA to 20mA; resistance from 100mΩ to 200GΩ; voltage from 10μV to 200V, and charge measurements from 10fC to 20nC. Keithley Instruments, Inc., 28775 Aurora Road, Solon, OH 44139. Tel: 800-552-1115; Fax: 216-248-6168.

Keithley Instruments

For More Information Write In No. 356

NEW 8½-DIGIT MULTIMETER UNDER $5,000



Keithley introduces the Model 2002 multifunction DMM with outstanding specifications for current, voltage, and resistance measurements. Sensitivity is 1nV, 10pA and 100nΩ accuracy is 6ppm DCV, 0.03% ACV, and 8ppm ohms. The 2002 features reading rates up to 2000/sec., resistance measurements from 100nΩ to 1GΩ, and frequency from 1Hz to 15 MHz. Keithley Instruments, Inc., 28775 Aurora Road, Solon, OH 44139. Tel: 800-552-1115; Fax: 216-248-6168.

Keithley Instruments

For More Information Write In No. 357



New Highly-Sensitive, Integrated K-Beam® Capacitive Accelerometer

Kistler K-Beam accelerometers give you unequaled stability and accuracy for the most demanding applications. They feature a built-in signal conditioner and a silicon micromachined sensor that eliminates piezoresistive and strain gauge zero drift. K-Beam operates from a 9-volt battery, and its low mass, compact design includes a detachable cable. Kistler Instrument Corporation, Tel: 716-691-5100; Fax: 716-691-5226.

Kistler Instrument Corporation

For More Information Write In No. 358



International Polymer Engineering custom manufactures melt thermoplastic profile extrusions and porous polyetrafluoroethylene (PTME) tubing sheets and rod components to customer established specifications. International Polymer Engineering specializes in precision controlled profiles and cut lengths with the catheter manufacturer in mind. P.O. Box 797, Tempe, AZ 85280-0797. Tel: 602-967-3265; Fax: 602-929-9799.

International Polymer Engineering

For More Information Write In No. 359

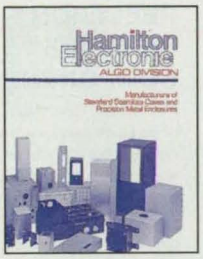


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Deltran Division, American Precision Industries

For More Information Write In No. 360



STANDARD METAL ENCLOSURES

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Hamilton Electronic Corporation

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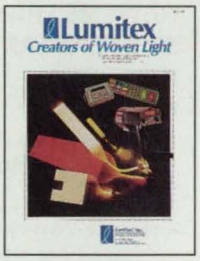


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SYSTRAN Corp.

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Lumitex, Inc.

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Rosemount Aerospace Inc.

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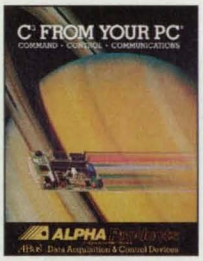


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LOW-COST, MODULAR DATA ACQUISITION AND CONTROL

FREE A-Bus product catalog from Alpha Products details an extensive line of data acquisition and control boards with Windows compatible software. Modular and low cost, the A-bus is ideal for rapid prototyping, laboratory/test applications and can substantially decrease new product time-to-market. Tel: 203-259-7713; Fax: 203-254-0169.

Alpha Products Company

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DATEL, Inc.

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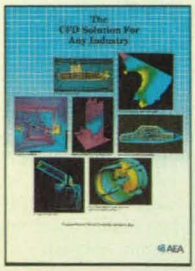


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Analogic Corporation

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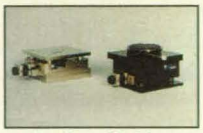


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For More Information Write In No. 370



DATA ACQUISITION SYSTEMS FOR PCs

A brochure from Strawberry Tree, Inc., Sunnyvale, CA, describes its data acquisition hardware and software products for PCs. Highlights include the new DATAshuttle family of parallel port A/D units, a full line of plug-in A/D boards, and the powerful, new Workbench software for Windows, DOS, and Macintosh.

Strawberry Tree, Inc.

Tel: 1-800-736-8810.

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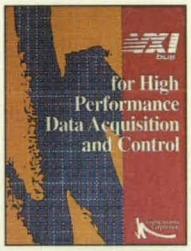


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Robinson Nugent, Inc.

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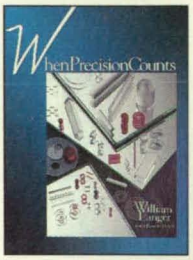


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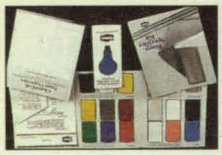


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FREE FOAM SAMPLE MATERIALS

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Voltek, Div. of Sekisui America Co.

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Magnetic Shield Corporation

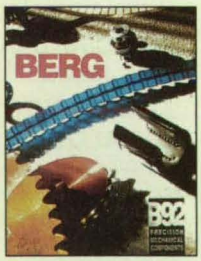
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EQUIPMENT HOUSING HARDWARE

Design Standards' new catalog presents an international selection of operational hardware for manual positioning, accessing, and controlling of equipment and machinery. The featured knobs, levelers, clamp levers, handwheels, spring loaded devices, hand grips and wheels possess superior production, functional and aesthetic qualities. Products are available in small quantities for immediate shipment. Design Standards, International Control and Access Hardware; a division of Rogan Corporation, Tel: 1-800-388-5656. Fax: 708-509-1705.

For More Information Write In No. 377



B92 CATALOG RELEASE

The latest catalog from W.M. Berg, Inc., coincides with Berg's silver anniversary. Founded in 1967, Berg has grown to become a recognized industrial leader of miniature precision mechanical components. A significant number of new items are added as well as expanding previous product lines. Featuring 50,000 standard components, 80% of which we are able to ship from stock within 24 hours. Available in metric version too: M92. Tel: 516-596-1700; Fax: 516-599-3274.

W.M. Berg

For More Information Write In No. 378



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Moritex U.S.A. Inc. of San Diego, California is proud to introduce its new and improved range of high contrast C-Mount optical lenses termed "Machine Micro Lenses (MMLs). These are small, light-weight lenses with fixed working distances and magnifications designed to be integrated in to Machine Vision Systems.

Moritex U.S.A.

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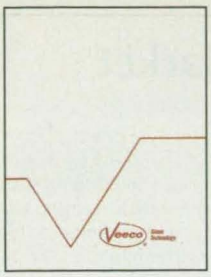


VACUUM VALVES

VAT'S new 225 page hardcover catalog contains detailed information and drawings on a comprehensive selection of gate, angle, all-metal, slit, fast-closing, throttle, and pressure control valves. Using innovative sealing technology, they are ideal for pump isolation, load-locks, beam lines, or other vacuum applications.

VAT

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Veeco/Sloan Technology

For More Information Write In No. 391



SURFACE MEASUREMENT SYSTEM

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For More Information Write In No. 390



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Clever Devices, Ltd.

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Just updated, Catalog #WS-93 contains **NEW stock sizes** of wave/compression springs available from stock, including spring design formulas, materials guide and typical applications. The manual describes the many advantages of Smalley's exclusive edgewinding manufacturing process. Smalley springs, available from 3/8" to 84" in diameter, are produced by circle-coiling flat wire to exact specifications involving **no dies or special tooling charges**. Tel: 708-537-7600; Fax: 708-537-7698.

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For More Information Write In No. 386



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A new 4-color, 190-page Danfoss catalog provides an overview of the VLT 3000 Series of AC drives (spanning 1 to 300 HP); AC controls; Cycletrol Series DC controls; and RDS-20 DC adjustable speed controls. An AC Technical Reference section provides an in-depth review of AC motor technology and Danfoss' adjustable frequency drive technology. Tel: 815-398-2770; Fax: 815-398-2869.

Danfoss Inc., Electronic Drives Division

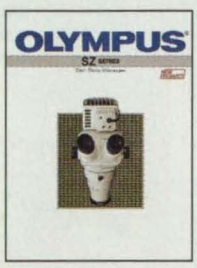
For More Information Write In No. 387



Metrum's new 60-page product catalog highlights features and specifications of its entire family of instrumentation recording products, including reel-to-reel analog recorders, laboratory recorders, and portable digital cassette-based tape recorders. The catalog also contains Metrum's peripheral and imaging products, plus highlights of the company's 35-year instrumentation history.

Metrum

For More Information Write In No. 388



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Olympus Corporation

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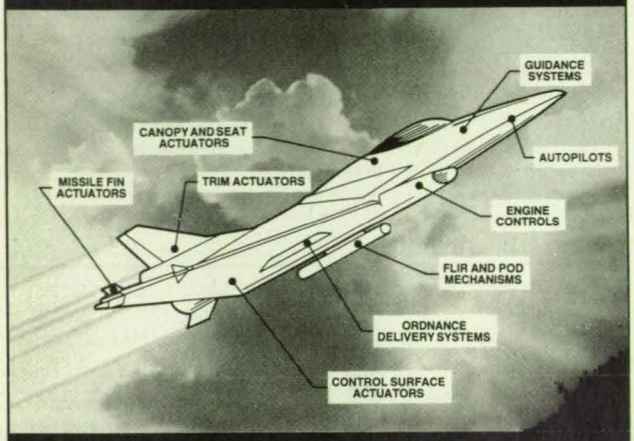
POSITION TRANSDUCERS

New 4/C, 16-page Engineering Guide describes how to select and use Inductosyn® position transducers for demanding applications. Accuracies are better than ±40 microinches for linear units and ±0.5 arc second for rotary units. Specifications given for representative incremental and absolute units. Tel: 914-761-2600; Fax: 914-761-0405.

Farrand Controls

For More Information Write In No. 380

ELECTROID Aerospace Components

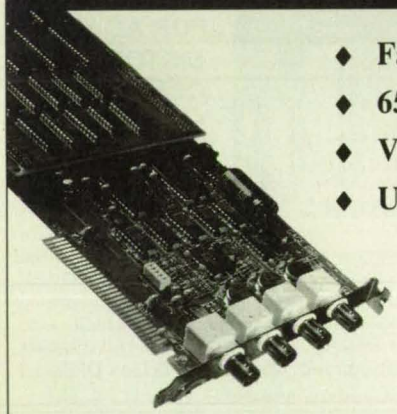


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For More Information Write In No. 498

New on the Market

The SDS™ **distributed machine control system** from the Micro Switch Division of Honeywell Inc., Freeport, IL, changes sensors and actuators from change-of-state devices to intelligent communication and control devices through a robust, open network. By bringing communications to the device level on the factory floor, the SDS bus system reduces downtime and both installation and operating costs. The SDS interfaces with any programmable logic controller or PC.

For More Information Write In No. 702

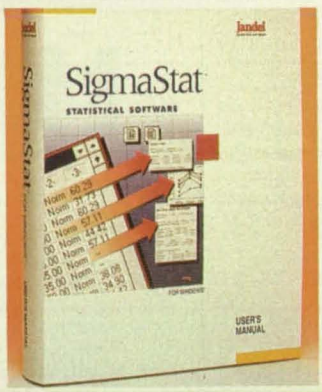


NeuralWare Inc., Pittsburgh, PA, has unveiled the first **fuzzy logic system for business applications**. Dubbed *FuzzySP*, the software offers decision support for risk assessment, market share and sales analysis, portfolio mix optimization, asset and resource allocation, and new product pricing. *FuzzySP* enables construction of fuzzy systems specific to the financial services, transportation, biotechnology, marketing, and medical service industries.

For More Information Write In No. 704

SigmaStat™ **statistical software** for scientific and engineering research from Jandel Scientific, San Rafael, CA, is now available for MS-Windows. The package helps users select the most appropriate tests, checks their assumptions, handles missing data, and explains the results. The new release features descriptive statistics, *t*-tests, analysis of variance, correlation, *z*-tests, chi-square tests, nonparametric methods, and linear, multiple linear, and nonlinear regressions.

For More Information Write In No. 703



DataMost Corp., Salt Lake City, UT, has announced StatMost, **statistical analysis and scientific graphic software** for microcomputers. Featuring a graphical user interface, the package performs advanced data management, statistical analysis, comprehensive numerical computation, time-series analysis, Fourier transform, nonlinear parameter estimation, and model development.

For More Information Write In No. 705

OKI Semiconductor, Sunnyvale, CA has introduced **surface acoustical wave filters** designed to filter bandpass frequencies in cellular, microwave RF, and fiber optics equipment operating in the 750 MHz to 2 GHz range. Packaged as miniature surface mount devices, the filters measure less than 23 mm for use in small, lightweight communications devices. With a total thickness less than 2 mm, they are well-suited for Type 2 PCMCIA and other wireless network card systems.

For More Information Write In No. 714



A miniature, computer-controlled **pan-tilt unit** introduced by Directed Perception, Burlingame, CA, performs at speeds over 300°/sec. with precise position control of 3.086 arc min. (.051°) resolution. Designed to direct video cameras and other small payloads, the PTU-46-17.5 measures just 3" x 5.11" x 4.25" and provides a load capacity of over four pounds.

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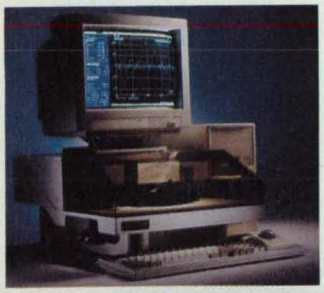
Presenter Professional 3.0, released by Visual Information Development Inc., Monrovia, CA, integrates **3D modeling, animation, and sound** in a design and multi-media package. Available for the Macintosh, the software provides spline-based modeling, Boolean operation, object morphing, TrueMotion™ time-based 3D animation, TrueSound™ virtual 3D audio, time-based script window, multiple cameras and lights, and velocity graphs for all object parameters.

For More Information Write In No. 710

New on the Market

A **surface profiling system** from Tencor Instruments, Mountain View, CA, provides precise analysis of step heights and microroughness on semiconductor wafers, ceramics, glass, and integrated circuit packages. Incorporating a 486DX-based computer, the Alpha-Step® 500 offers automatic leveling and cursor positioning. Up to 39 parameters, including step height, average roughness, and radius of curvature are automatically calculated from one measurement.

For More Information Write In No. 701



Xilinx, San Jose, CA, has unveiled the first 25,000-gate **field programmable gate array** (FPGA). Developed with 0.6 micron SRAM process technology, the new XC4025 nearly doubles the capacity of current FPGAs, providing 1024 configurable logic blocks and 256 user I/Os. With on-chip user RAM, total equivalent gate counts can exceed 36,000.

For More Information Write In No. 709

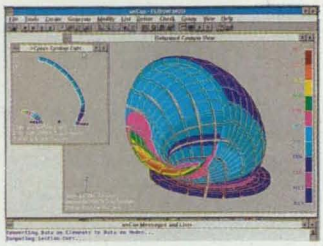


The patented MAXIR™ line of **filament lamps** from BHK Inc., Pomona, CA, offers models to produce a continuous spectrum from ultraviolet to far infrared, depending on the window material selected and the filament operating temperature. Currently available with sapphire or zinc selenide windows, the MAXIR lamps offer high thermal shock resistance, adjustable and high color temperatures, and broad spectrum emission to 20 m.

For More Information Write In No. 715

The Matrix line of compact **pneumatic valves** from Amatrix, Farmingdale, NY, are available in 2-, 3-, and 4-way configurations at 12, 24, and 48 VDC with an operating life exceeding 500 million cycles. Capable of replacing up to nine single valves, the Matrix valves feature 1 to 9 outlets with independent or simultaneous port opening for flow rates up to 34.95 scfm.

For More Information Write In No. 719



Windows-based **finite element analysis software** available from Aegis Software Corp., Pittsburgh, PA, features fast 32-bit object-oriented (C/C++) coding and Sol-View, a deformed shape plot for previewing results while a problem is being solved. Dubbed *Power Solver*, the program's analysis capabilities include linear static, linear frequency and mode shape, buckling, nonlinear static and dynamic, and linear and nonlinear steady-state heat transfer and transient heat transfer.

For More Information Write In No. 716

The versatile PentaCam 3000 from The Focal Point Inc., Weston, CT, can operate as an **electronic imaging device** to bring live or taped video into multimedia productions or individual frames into a computer; as a 35mm SLR to take still photographs; or as a 3-chip CCD camera to produce broadcast-quality live color video, capturing sound with near CD dynamic range. The PentaCam comprises a video head with an integral camera control unit, electronic color viewfinder, and a Nikon F45. Employing 380,000-pixel interline transfer hyper HAD sensors, the camera produces images with 750 TV lines horizontal resolution and a S/N ratio of 58 dB.

For More Information Write In No. 711



The latest release of DataSponge™ **data acquisition software** from World Precision Instruments, Sarasota, FL, offers increased speed, improved display resolution and data storage, and flexible printing capabilities. New features include Postscript support, on-the-fly data annotation, X-Y oscilloscopic display, and instant digital readouts during sampling or playback.

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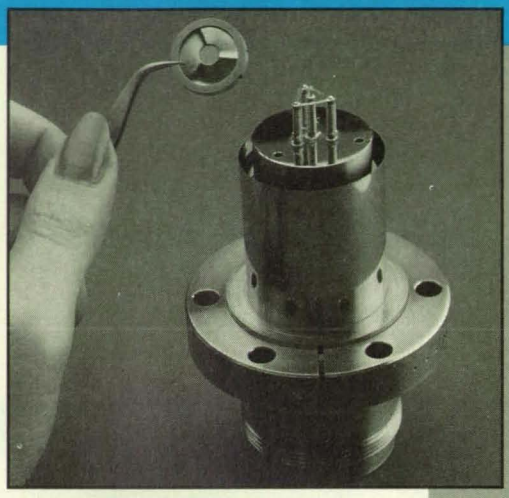
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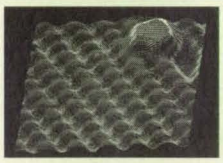
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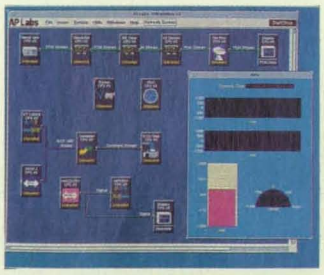
RGB Spectrum, Alameda, CA, has released the SynchroMaster 100 **field sequential scan converter** to interface head-mounted displays with a variety of workstations, scene generators, and simulators. Displays used for simulation and training must offer high resolution and wide angle views to achieve a credible virtual reality. Built to provide the required color sequential signal, the stand-alone SynchroMaster 100 accepts a broad range of graphic input signals up to 1280 x 1024 pixels.

For More Information Write In No. 700



AP Labs Inc., San Diego, CA, has released a **graphical user interface** for setup and control of real-time VME systems. VMEwindow™ software uses X/Motif™ to provide a highly-configurable, icon-based mechanism for direct control of a wide variety of VME I/O cards. Users can configure and execute data acquisition, analysis, storage, and I/O systems by manipulating a flow graph of icons representing VME boards, software analysis and display tasks.

For More Information Write In No. 707



TEAC America Inc., Montebello, CA, has unveiled the TEAC SUPER QUAD, a low-cost AT proprietary **CD-ROM drive** with a data transfer rate of 600 kB/sec.—four times faster than a single-speed drive. Priced at $399, the drive features an access time of 220 msec. and a data buffer of 64 kB in a 5¼" x 1" high standard form factor. It supports CD-ROM extended architecture and has a multisession photo CD capability.

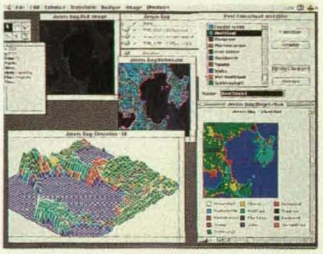
For More Information Write In No. 718





A new general-purpose, high-resolution **digital camera** from Eastman Kodak Co., San Diego, CA, captures real-time images at 30 frames per second. The Model XHF Megaplus incorporates a million-pixel CCD sensor with highly reliable electronic shutter action. A broad dynamic range with eight bits per pixel permits the camera to record 256 discernible levels of grey scale.

For More Information Write In No. 717



DIMPLE software from Cherwell Scientific, Brookline, MA, is an interactive **image processing system** for earth sciences that supports image analysis and enhancement, multispectral transformations, supervised/unsupervised classifications, and image registration and rectification. Available for the Macintosh, DIMPLE supports both raster and vector data, and 24-bit images.

For More Information Write In No. 712

New additions to the UNIFAST line of **industrial fasteners** from USM Corp., Wilmington, MA, include precision metallic nail, tack, and pin fasteners for the broom, brush, and mop industries. The company's fasteners are designed with precision tolerances for machine inserted or high quality applications such as automated production and are available in a wide range of metals, threads, and finishes.

For More Information Write In No. 713

O-Matrix®, an **object-oriented visual analysis and modeling** package for PCs, has been introduced by Harmonic Software Inc., Seattle, WA. O-Matrix is a matrix-based, interpreted language that performs operations on matrices instead of individual numbers. Functions include signal processing, spectral analysis, differential equations, optimization, Kalman filtering, wavelets, FFTs, Eigenvalues, statistical analysis, and GPS positioning.

For More Information Write In No. 706

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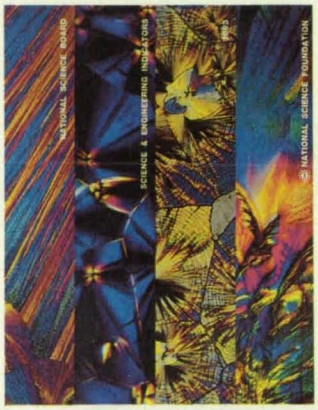
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For More Information Write In No. 489

New Literature

High-performance **EMI-filtered connectors** are showcased in a catalog from Spectrum Control Inc., Erie, PA. Designed to meet military specifications, the connectors are available in both an extended shell design and an innovative compact shell. Technical information describes how to determine the most efficient way to filter a connector.
For More Information Write In No. 724



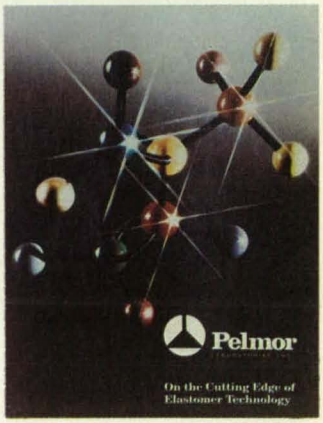
R&D expenditures from all US sources totaled $161 billion in 1993 according to a report from the National Science Board, Arlington, VA. The eleventh edition of ***Science and Engineering Indicators*** provides a broad and quantitative base for assessing US science and technology. It includes information on science and engineering education; employment; technology development and competitiveness; collaborations among government, industry, and university; and public affairs.
For More Information Write In No. 734

A technical note describing **digital oscilloscope applications in high-speed electronics** is available from LeCroy Corp., Chestnut Ridge, NY. Topics include the effects of scope bandwidth and sample rate on the measurement of both repetitive and single-shot signals, problems making measurements in the presence of noise, cross channel timing measurements, crosstalk, microprocessor crashes, timing problems due to clock skew, metastability, probes, and using long memory to gain higher effective bandwidth.
For More Information Write In No. 733

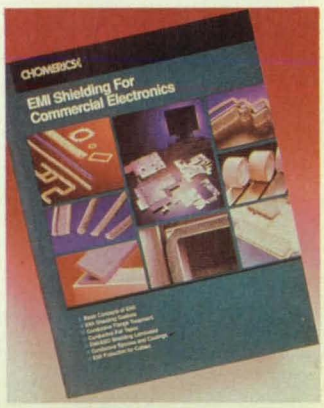
A 1104-page **data acquisition** data book is available from Harris Semiconductor, Melbourne, FL. Sections focusing on A/D converters discuss displays, integrating, successive approximation, flash, and subranging. Other sections address D/A converters, switches, multiplexers, RS-232 communications interface ICs, display drivers, and counters with display drivers/timebase generators.
For More Information Write In No. 723

A 95-page reference book on high-performance **data acquisition and control** has been published by Kinetic Systems Corp., Lockport, IL. The guide traces the data acquisition process from sensor output through archival of data for analysis. It examines VXI and other bus standards, antialias filtering, grounding, calibration, ADC quantization noise, Sigma-Delta converters, latency, and software.
For More Information Write In No. 732

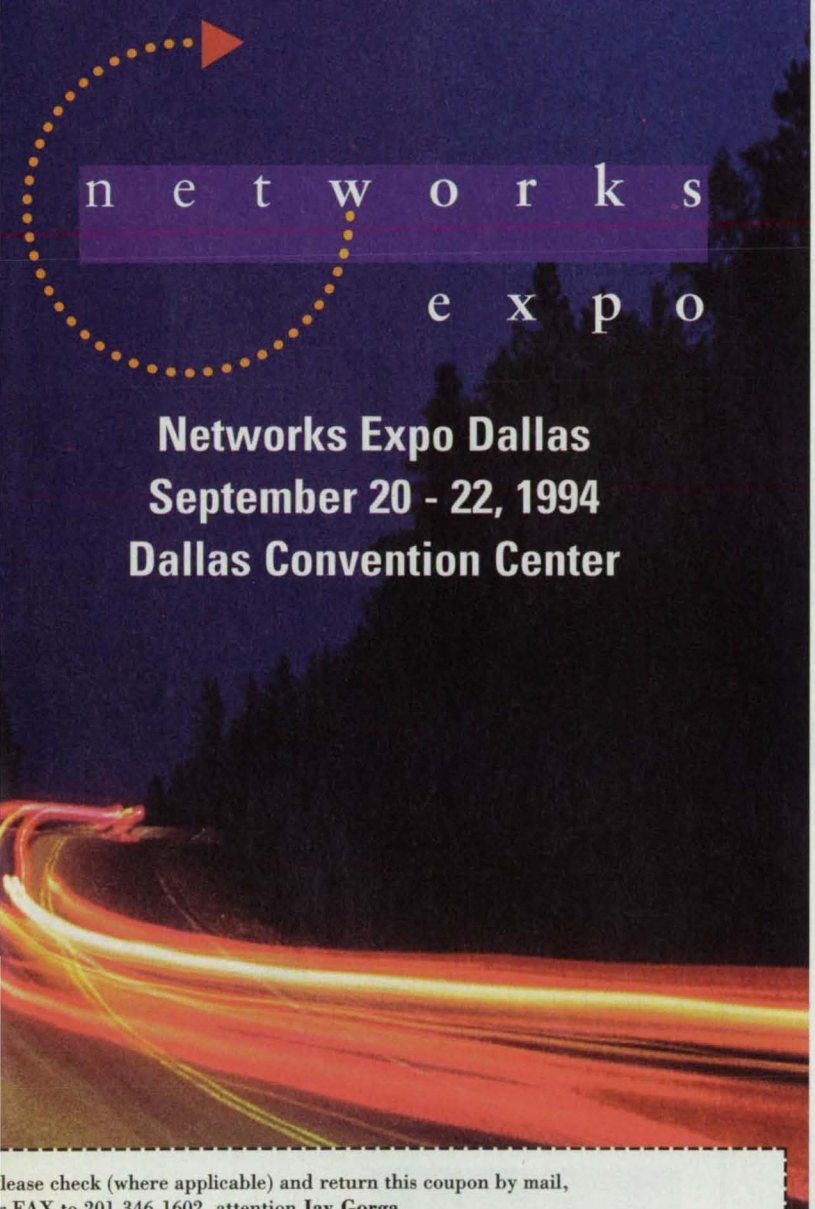
Pelmor Laboratories Inc., Newtown, PA, which manufactures custom **natural and synthetic rubber parts**, has published a 12-page capabilities brochure. It describes product development services, including formulation mixing and design of tools and dies, and production capabilities such as injection, transfer, and compression molding and rubber-to-metal bonding. High-performance fluoroelastomer coatings, sealants, and adhesives are highlighted.
For More Information Write In No. 722



Chomerics, Inc., Woburn, MA, has released a catalog of **EMI shielding** products for commercial electronics. It describes EMI gaskets, foil tapes, foil/film laminates, and protection systems for cables. The publication explains basic EMI concepts, typical shielding applications, and EMI gasket attachment systems.
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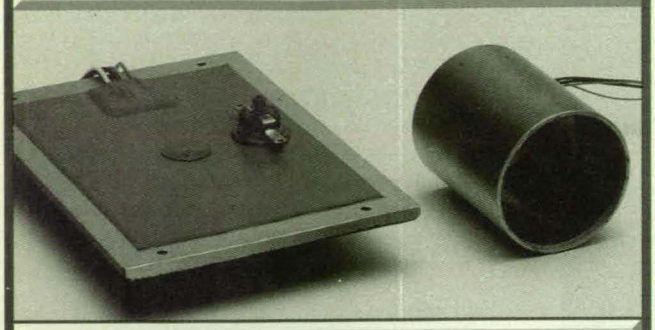
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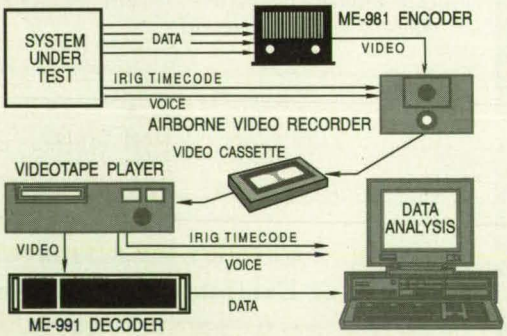
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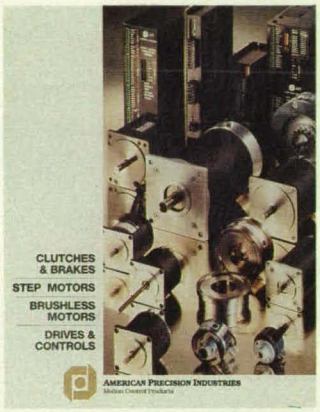
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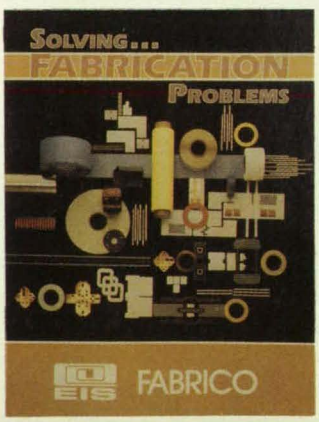
New Literature

The Motion Control Group of American Precision Industries, Buffalo, NY, has released a guide to products from its three divisions: The Controls Division provides a line of drives, controls, power supplies, and stepping motors. Electromagnetic clutches and brakes used in rotary control are available from the Deltran Division. The Rapidsyn Division manufactures step motors, AC synchronous motors, linear actuators, and high-performance brushless DC motors.
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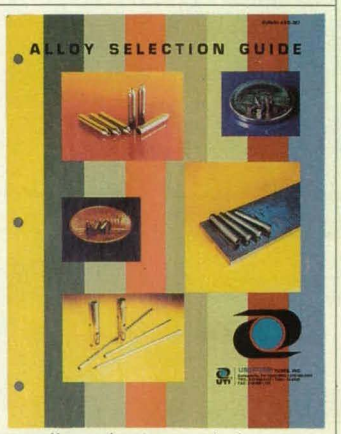
Actuators to solve common manufacturing problems are showcased in a brochure from Bimba Manufacturing Co., Monee, IL. The company's stainless steel body air cylinders, Pneu-Turn® rotary actuators, and Ultran rodless cylinders offer increased speed and reduced downtime and cost in applications such as cutting, lifting, and positioning.
For More Information Write In No. 729

The Fabrico Division of Electrical Insulation Suppliers Inc., Atlanta, GA, has released a 100-page catalog and guide to solving **fabrication** problems. Featuring the company's conversion and specialty equipment, it provides technical reference data on electrical insulation, pressure-sensitive tapes, gasket materials, and EMI/RFI shielding.
For More Information Write In No. 725



Bison Gear and Engineering, Downers Grove, IL, has introduced a **gearmotor sizing** guide that divides the rating process into five activities: determining torque, adjusting for duty cycle, determining overhung load, factoring in the application's shock load, and selecting input motor characteristics. In addition, calculations are provided for determining input motor horsepower, gearmotor efficiency, output horsepower, form factor, and wattage measurements.
For More Information Write In No. 727

The illustrated *Encyclopedia of PC Main Boards* from Jensen Tools Inc., Phoenix, AZ, offers data on more than 850 **motherboards**. The 2500-page, six-volume set includes a reference volume describing motherboards, coprocessors, chipsets, memory and cabling configurations, bus interfaces, crystals, batteries, switches, I/O and power connections, and BIOS. Other volumes contain diagrams of motherboards showing major component locations, slots, jumpers, and switches.
For More Information Write In No. 726



An alloy selection guide from Uniform Tubes Inc., Collegeville, PA, helps users select **miniature metal tubing** for specific applications. It describes the chemical composition, physical properties, and mechanical characteristics of more than 65 metals and alloys. Tubes are available in diameters from 15.875 to 0.0762 mm, wall thicknesses from 1.2446 to 0.0127 mm, and to tolerances of ±0.000000635 mm.
For More Information Write In No. 721

The ***High Temperature Materials Handbook*** from Cotronics Corp., Brooklyn, NY, offers information on machinable and castable ceramics, foams, tapes, adhesives, protective coatings, and ceramic cloths for use up to 2200 °C. New products include epoxy, repair, and maintenance compounds formulated for continuous high temperature use.
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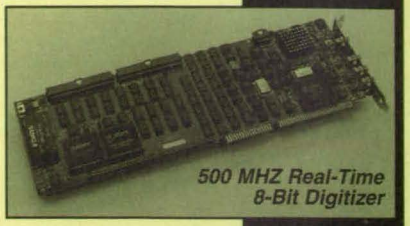
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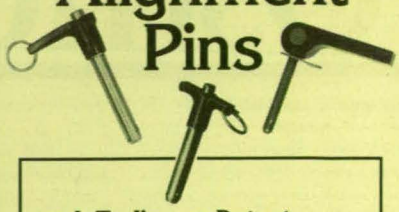
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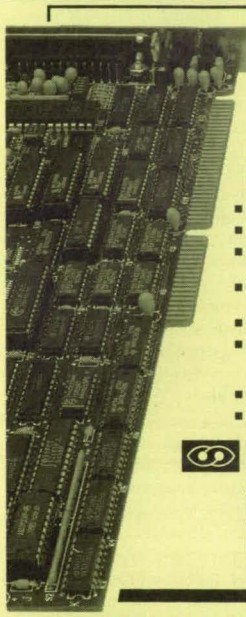
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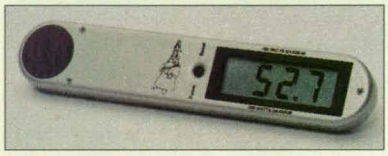


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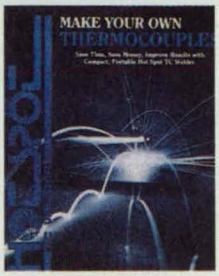
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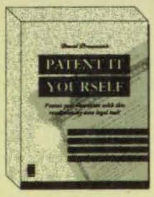
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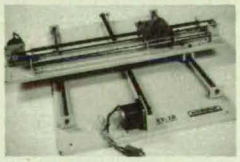
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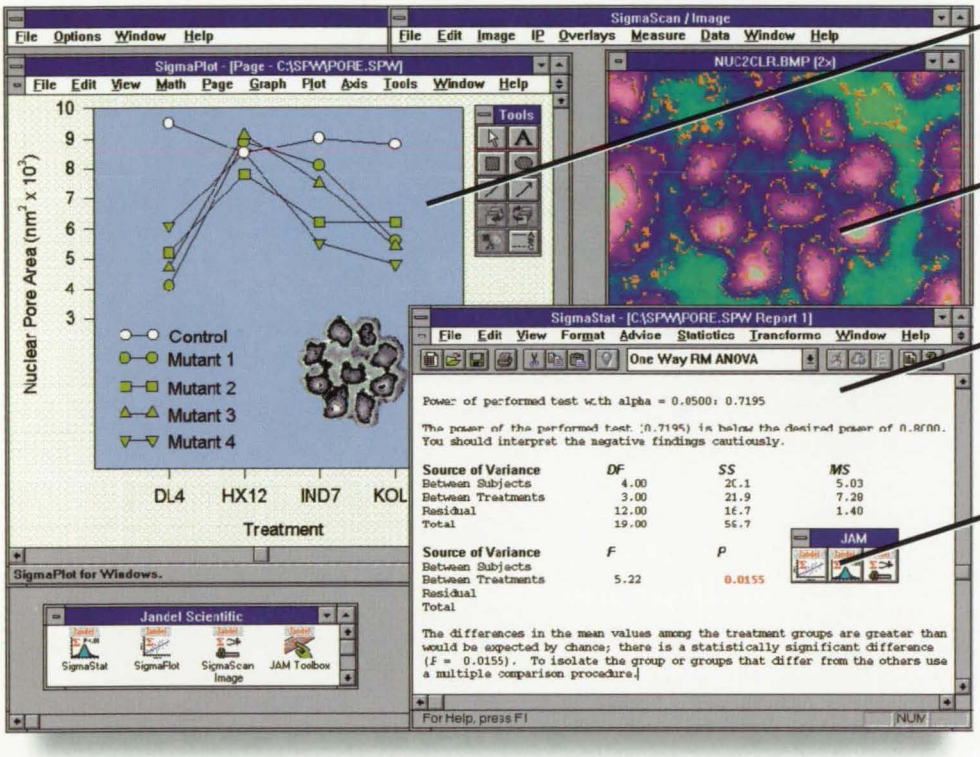
The first annual Small Business Innovation Research (SBIR) Technology of the Year Awards will be presented this November in Washington, DC in conjunction with the Technology 2004 national technology transfer conference & exposition. Phase II and III SBIR companies that have developed novel, commercially-important technologies and products through SBIR funding are invited to submit nominations and exhibit at Technology 2004.
For a complete nomination package, write in no. 424 or call Wayne Pierce at (212) 490-3999.

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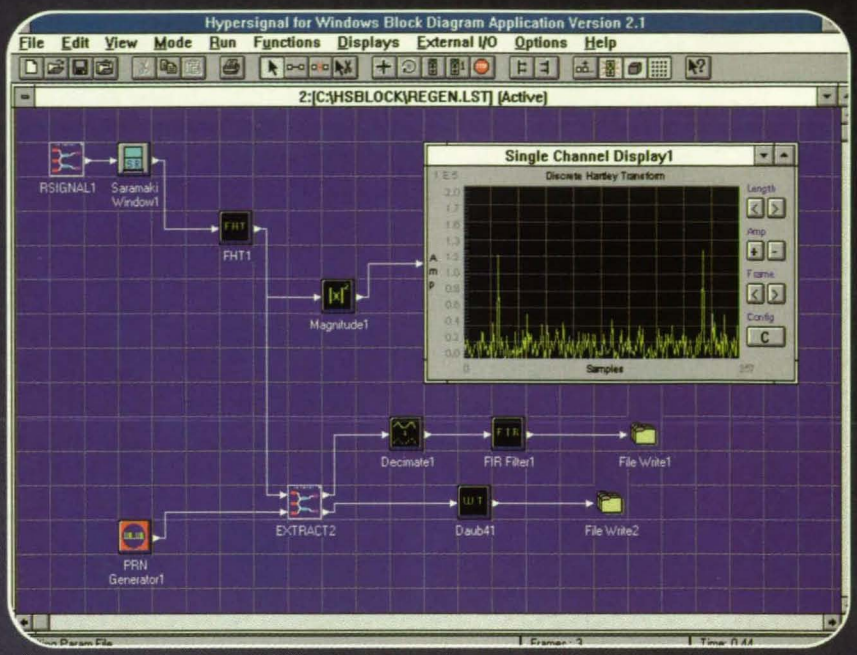
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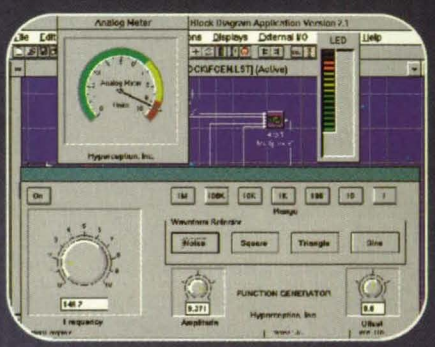


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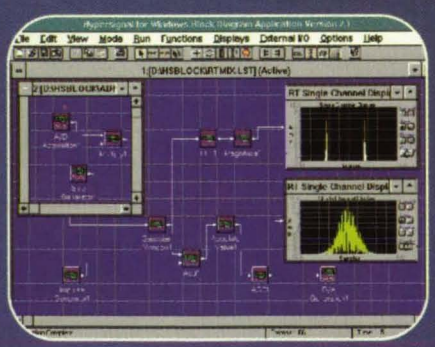
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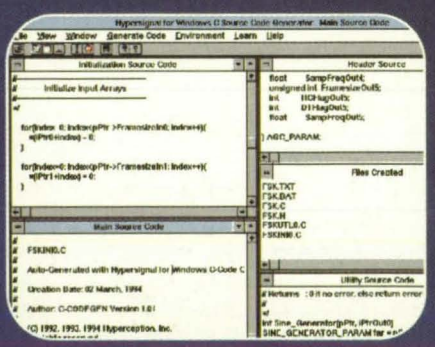
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